BIOLOGICAL METRICS FOR REGIONAL BIOMONITORING AND ASSESSMENT OF SMALL STREAMS IN IDAHO

FINAL REPORT

Prepared by

Christopher T. Robinson and G. Wayne Minshall

Stream Ecology Center
Department of Biological Sciences
Idaho State University
Pocatello, Idaho 83209

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SUMMARY

The initial goal of this project was to develop and test a biological assessment program, based on macroinvertebrate and fish assemblages, for wadeable (2nd-4th order) streams in the Northern Basin and Range (NBR) and Snake River Plain (SRP) ecoregions of southern Idaho. This report combines data collected in 1990, 1991, and 1993 from 60 streams (NBR, N=32; SRP, N=28) sampled in these two major ecoregions. Efforts concentrated on upland and lowland stream types. Lowland streams impacted by livestock grazing were used for refinement and validation of developed metrics. In 1993, we incorporated the Northern Rocky Mountain (NRM) ecoregion through inclusion and adaption of Fisher's (1989) data along with 10 streams sampled in the Big Creek and Panther Creek catchments. Here, five streams impacted by mining operations were used for metric validation.

Based on data collected in 1990 we found a quantitative sample (modified Hess sampler, 250-μm mesh) to be as fast and provide additional information for macroinvertebrates (e.g., taxon density) and better resolution among stream types than a qualitative kick sample. In addition, a single pass of the electrofisher was effective for fish in streams with low turbidity and low fish densities, but a three-pass approach was needed when streams were turbid and/or had high fish densities. These findings permitted improvements in sampling efficiency which became the standard methodology in 1991 and 1993.

Work in 1991 and 1993 provided data from additional sites in both ecoregions. Habitat data collected in 1991 revealed that additional quantitative variables (e.g., maximum water temperature, specific conductance, alkalinity, nitrate, and phosphorus levels) were important in distinguishing streams among and within ecoregions. Analysis of the macroinvertebrate data showed that biotic metrics for discriminating among stream types may differ among ecoregions. Fish metrics primarily focused on the presence of Salmonidae because of the relatively depauperate number of fish species in intermountain streams. The presently developed biotic metrics provide a suitable approach for

monitoring biological integrity for streams in the Northern Basin and Range and Snake River Plain ecoregions.

In 1993, using habitat and benthic data from tributaries of Big Creek and Panther Creek, we determined the feasibility of using Fisher's (1989) data set for the development of biotic metrics for biomonitoring small streams in the NRM ecoregion. The results suggest good potential for incorporation of this data set. However, additional impacted sites, currently N=5, are required for metric refinement and validation. Mining-impacted streams also showed the importance of including certain chemical measures in assessing aquatic habitats.

INTRODUCTION

Freshwater systems, both lakes and streams, continue to remain seriously degraded from non-point source pollutants and alteration of the physical habitat (Benke 1990, Hughes et al. 1990, Karr 1991, Hughes and Noss 1992, Allan and Flecker 1993). Non-point source pollution is closely associated with land use practices (Steedman 1988, Richards et al. 1993) and degree of impact is related to geographical region (Hughes et al. 1990, Matthews et al. 1992). The Clean Water Act directs the U.S. Environmental Protection Agency to develop programs to evaluate, restore, and maintain the chemical, physical, and biological integrity of the Nation's waters. For some time, evaluation of water quality has focused on chemical criteria and single-factor laboratory toxicity tests. Because of the nature of non-point source pollution (e.g. sedimentation) and changes in physical habitat, alternative methods from a strict water quality standpoint are required for assessing the biotic health of freshwater systems.

A regional approach to the assessment on non-point source pollution has been adopted to account for geographical differences (variability) in freshwater habitats and fauna (Gallant et al. 1989, Hughes et al. 1990) and potentially provide a cost-effective procedure for state and national biomonitoring. Early regionalization was primarily based on chemical attributes of aquatic systems (e.g. Omernik 1987), with later refinements towards an ecoregion (areas of similar geography, hydrology, climate, chemistry, terrestrial vegetation, and biota) approach to increase organization in bioassessment and biomonitoring at the state and national levels (Bailey 1989, Hughes et al. 1990). Presently, numerous states have implemented an ecoregion approach for assessing biological health in relation to land use patterns (e.g. Fausch et al. 1984, Gallant et al. 1989). An ecoregion approach provides a means for assessing biological integrity and facilitating the development of recovery criteria within and among different regions of the landscape.

Rapid bioassessment protocols have become an important tool in assessing the biological integrity of freshwater ecosystems in a cost effective manner (Plafkin et al. 1989, Karr et al. 1986, Karr 1991). Rapid bioassessment attempts to combine aspects of water quality with other physical measures of the habitat in order to more fully assess overall habitat quality (Rosenberg and Resh 1993). In addition, protocols were developed for evaluating the biotic components (e.g. fishes, macro-invertebrates, algae) of freshwater systems to provide an integrative ecosystem level assessment of biological integrity (Bramblett and Fausch 1991, Barbour et al. 1992, Reice and Wohlenberg 1993). Indeed, the state of Idaho recently drafted a number of monitoring protocols for assessing biological integrity using both fish (Chandler and Maret 1993) and macroinvertebrates (Clark and Maret 1993) in conjunction with habitat evaluation guidelines (Burton 1991, Burton et al. 1991).

The present study incorporated rapid bioassessment protocols for evaluating the biological integrity of streams in two ecoregions, the Northern Basin and Range (NBR) and Snake River Plain (SRP), located within Idaho. Rapid bioassessment protocols are based on a strong theoretical framework in community and ecosystem ecology, however modifications of metrics are required to adjust nationally derived or general criteria to specific regional conditions (Steedman 1988, Barbour et al. 1992, Resh and McElravy 1993). Rapid bioassessment protocols were originally developed for the "time" and cost effective collection of biological data, thereby potentially compromising data completeness (e.g. the use of qualitative collection techniques) and reliability (e.g. no measure of data variability resulting in a loss of statistical power and potential for Type II errors) (Resh and Jackson 1993).

The overall goal of the present project was to develop and test a biological assessment program for wadeable (2nd-4th order) streams in Idaho. During 1990 and 1991, we focused our work on the NBR and SRP ecoregions in the southern part of the state (Robinson and Minshall 1991, 1992). In 1993, we expanded this goal to include the Northern Rocky Mountain (NRM) ecoregion;

these three ecoregions cover >80% of the land-area in Idaho. However, data acquisition and analysis differed for the NRM ecoregion and thus will be addressed in separate sections of the report. In order to incorporate the NRM ecoregion into our analysis in a cost-effective way, we examined the feasibility of adapting the extensive data set of Fisher (1989) to the modified protocol developed for the NBR and SRP. Habitat evaluations were completed for 25 streams that were sampled previously by Fisher; and macroinvertebrates were collected from four of these sites to provide for a relative quality assurance/control for that aspect. Further, a number reference sites from the Big Creek and Panther Creek catchments were included to increase sample size for the NRM ecoregion. We examined the responsiveness of the modified protocol in streams impacted by land uses characteristic of the particular region: NBR and SRP - livestock grazing; NRM - mining.

Specific objectives regarding all three (NBR, SRP, and NRM) ecoregions included:

(1) To establish reference conditions for streams in each ecoregion through investigations of "least" impacted or undisturbed examples. The reference condition serves as the point of comparison for determining attainment or non-attainment and for developing predictive models (generalizations) regarding stream health for a particular area (ecoregion).

(2) To validate and calibrate the ecological assessment approach for each ecoregion by comparing biological conditions in degraded streams with conditions in reference streams. Objective 2 was met by examining a variety of biotic metrics used to assess biological integrity and determining their respective applicability to conditions found in each ecoregion. Degraded streams used for validation and calibration in the NBR and SRP were anthropogenically perturbed locations representative of the major land-use practice in the area: livestock grazing. Likewise, mining-degraded streams in the Panther Creek drainage were used for metric validation in the NRM ecoregion.

(3) To determine if reference streams differ significantly among ecoregions, and whether upland streams differ from lowland streams within the same ecoregion. Streams in both the NBR and SRP were partitioned to cover both upland (forested, high gradient) and lowland (non-forested, low gradient) habitat types; and

(4) to develop a standardized field collection methodology for use by resource managers in biomonitoring streams of Idaho.

METHODS

Selection of Study Sites in the NBR and SRP Ecoregions

Study sites were selected from candidate streams by reviewing existing literature concerning site conditions, discussions with various agency personnel (Bureau of Land Management, Idaho Division of Environmental Quality, Idaho Department of Fish and Game, and United States Forest Service) and private land owners, and by field reconnaissance. Where possible, special effort was made to select designated "stream segments of concern" (Clark 1990, Dunn 1990). Sixty streams, of 95 examined during the summers of 1990, 1991 and 1993 (Appendix A), were selected for field sampling and data analysis. The 60 sites analyzed were comprised of 32 NBR streams and 28 SRP streams (Fig. 1). Maps for these specific sites are included as Appendix B.

Stream types analyzed included upland, lowland, and degraded lowland sites on 2nd-4th order streams (Strahler 1957). Upland sites were characterized generally as having greater slopes, more turbulent flow, and higher elevations than lowland sites. Further, upland sites were typically located in forested watersheds, whereas lowland sites generally were found in sagebrush/grass areas (Fig. 2). Representative degraded sites were lowland areas perturbed primarily by livestock grazing and other nonpoint source agricultural inputs. Lowland streams,

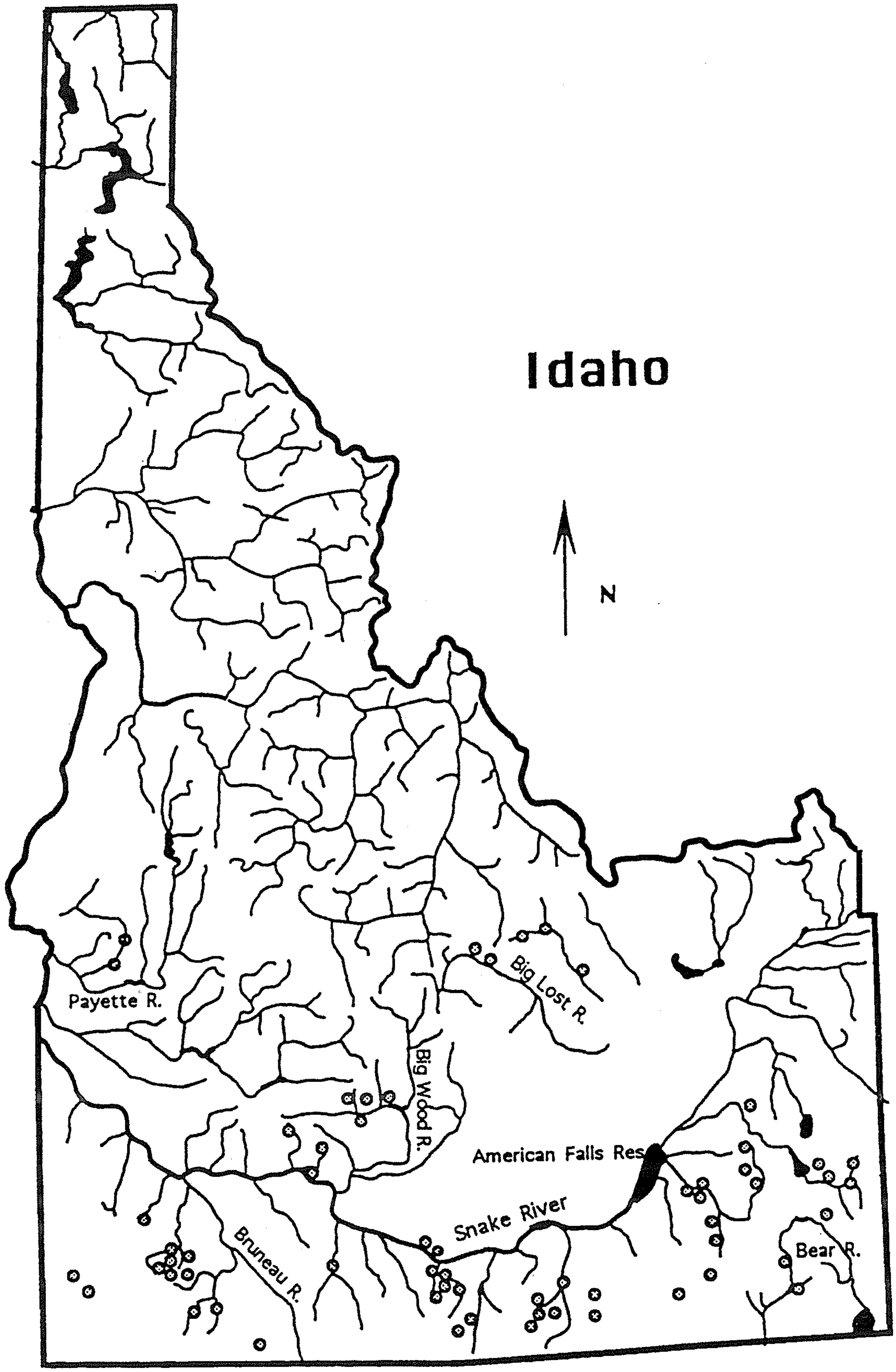
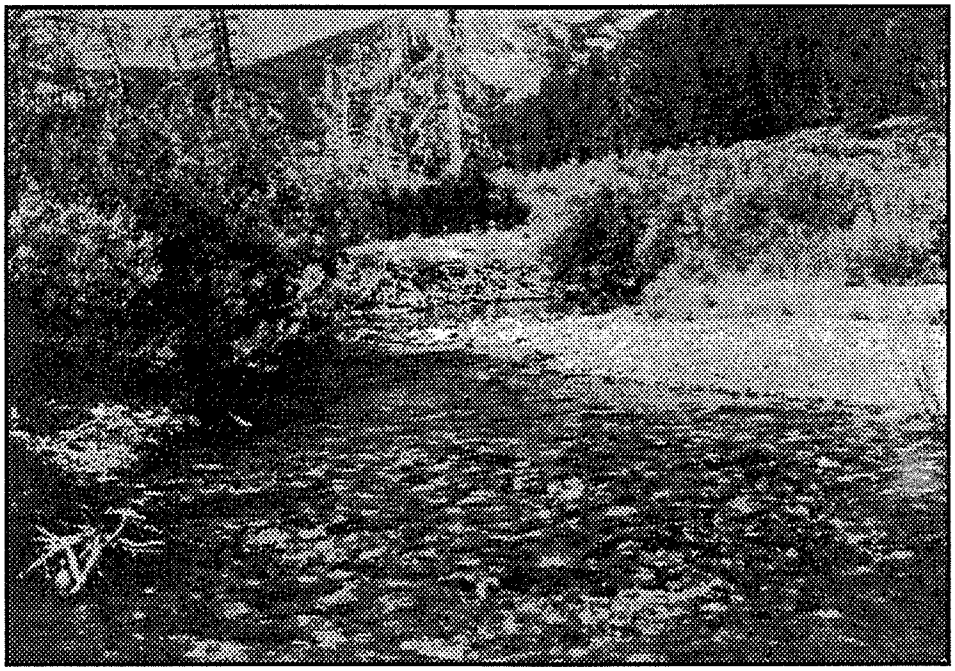


Fig. 1. General locations of study streams in the Northern Basin and Range and Snake River Plain ecoregions. See appendix B for exact location maps for each study site.



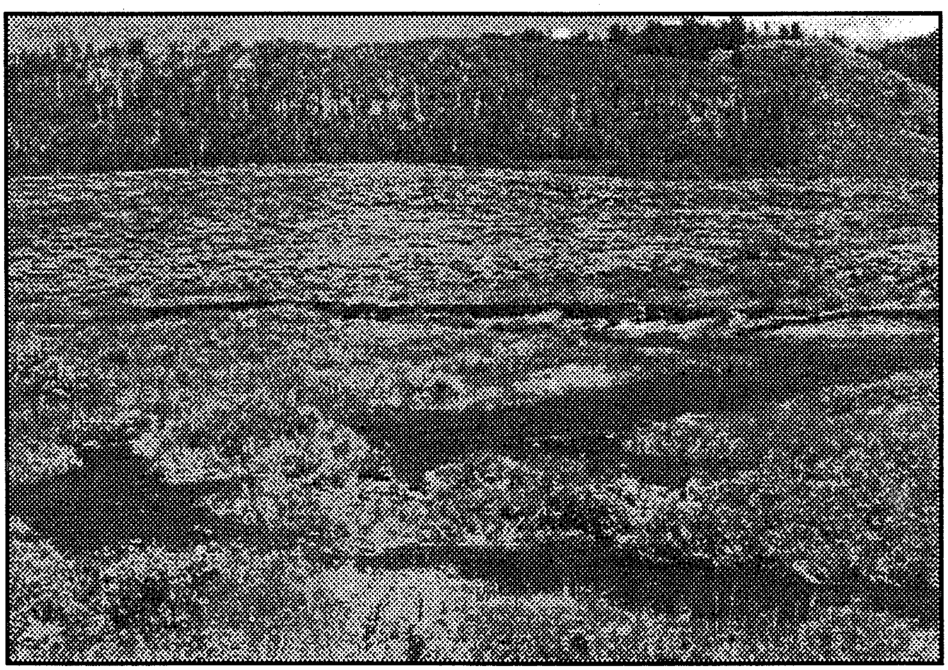


Fig. 2. Photographs of typical upland and lowland streams showing respective riparian and watershed habitats.

because they displayed a range in the degree of degradation, served for metric validation. Of the 32 streams analyzed in the NBR 13 were upland and 19 lowland, while of the 28 streams analyzed in the SRP, 18 were lowland and 10 upland.

Field reconnaissance provided an important avenue for final selection of study sites from the candidate streams. Initial logistic planning in the laboratory using 1:100,000-scale planimetric maps made field reconnaissance more efficient. This procedure was emphasized because of the often remote nature and widely separated locations of field sites. For example, field site locations ranged from the Idaho/Wyoming border to the Idaho/Oregon border and often were accessible via a dirt track or by foot. However, some sites were examined on an impromptu basis while en route to a scheduled site.

A two-part habitat assessment data sheet was used during field reconnaissance (Table 1). The first page provided for detailed information on physical and chemical characteristics for each site. These characteristics included: stream slope (hand-held clinometer), elevation (from topographic maps), width/depth ratio, mean width, % canopy cover, land-use, vegetative characteristics, discharge, riparian conditions, substrate measures, water temperature, pH, specific conductance, alkalinity, hardness, nitrate, phosphorus, and turbidity. References for specific measures are located in Table 2.

The second part included a habitat assessment field survey which allowed for the tally of an overall habitat score based upon a qualitative ranking of 12 categories (Appendix C)(Plafkin et al. 1989, Clark and Maret 1993). Selection of specific categories on the habitat assessment field data sheet differ for turbulent versus nonturbulent stream flow, i.e. whether a site consists predominantly of riffle/run or glide/pool habitat conditions (Table 1). The score for each category also is weighted in respect to its importance in describing habitat quality. Habitat assessment generally required about 1-2 person-hours per stream, once at the site. Field crews also completed a habitat assessment field data sheet at the time of sampling if habitat conditions had changed since time of field

Table 1. Field data sheet used in the study.

IDAHO ECOREGION - HABITAT ASSESSMENT FIELD DATA SHEET

ECOREGION: ______________________________
STREAM/TYPE: ____________________________
DATE/RECORDER: __________________________

GENERAL PHYSICAL CHARACTERISTICS
STREAM ORDER:
STREAM SLOPE:
SITE ELEVATION:
DISCHARGE:

STREAM WIDTH: _____, _____, _____, _____, _____

DEPTH: (1) _____, _____, _____, _____, _____, _____, _____, _____, _____, _____
(2) _____, _____, _____, _____, _____, _____, _____, _____, _____, _____
(3) _____, _____, _____, _____, _____, _____, _____, _____, _____, _____
(4) _____, _____, _____, _____, _____, _____, _____, _____, _____, _____
(5) _____, _____, _____, _____, _____, _____, _____, _____, _____, _____

PERCENT CANOPY COVER:
RIPARIAN ZONE WIDTH: rt bk _____, _____, _____ lft bk _____, _____, _____
SUBSTRATE: T-1 _____, _____, _____, _____, _____, _____, _____, _____, _____, _____
T-4 _____, _____, _____, _____, _____, _____, _____, _____, _____, _____

LAND-USE
ADJACENT TO STREAM:
WATERSHED:

IN-STREAM VEGETATION:
RIPARIAN VEGETATION:
WATERSHED VEGETATION:

BANK EROSION PRESENT:
NPS POLLUTION EVIDENT:

WATER QUALITY
TEMPERATURE:
pH:
CONDUCTIVITY:
TURBIDITY:
HARDNESS:
ALKALINITY:
PHOSPHORUS:
NITROGEN:

WEATHER CONDITIONS:
PHOTOGRAPH NUMBER:
COMMENTS
ACCESSIBILITY:
LOCATION:
OWNERSHIP:

Table 1 (cont).

HABITAT ASSESSMENT FIELD DATA SCORING SHEET

ECOREGION: ____________________

STREAM/TYPE: ____________________

DATE/RECORDER: ____________________

SCORE ____________

RIFFLE/RUN (UPLAND)	GLIDE/POOL (LOWLAND)
1. SUBSTRATE/COVER	1. SUBSTRATE/COVER
2. EMBEDDEDNESS	2. POOL SUBSTRATE TYPE
3. FLOW/VELOCITY	3. POOL VARIABILITY
4. CANOPY COVER	4. CANOPY COVER
5. CHANNEL ALTERATION	5. CHANNEL ALTERATION
6. BOTTOM SCOURING AND DEPOSITION	6. DEPOSITION
7. POOL/RIFFLE or RUN/BEND RATIO	7. CHANNEL SINUOSITY
8. WIDTH/DEPTH RATIO	8. WIDTH/DEPTH RATIO
9. UPPER BANK STABILITY	9. UPPER BANK STABILITY
10. BANK VEGETATION	10. BANK VEGETATION
11. STREAMSIDE COVER	11. STREAMSIDE COVER
12. RIPARIAN WIDTH	12. RIPARIAN WIDTH

RANKINGS:

PARAMETER	EXCELLENT	GOOD	FAIR	POOR
1-4	16-20	11-15	6-10	0-5
5-8	12-15	8-11	4-7	0-3
9-12	9-10	6-8	3-5	0-2

reconnaissance. For example, some initial visits were completed during high flows, while sampling was completed during baseflow conditions.

Collection Procedures for Physical and Chemical Measures

Average water depths and bank-full widths were calculated at each study site from five transects 50 m equidistant (Table 2). Canopy cover was estimated for the entire reach and presented as quartile percent, i.e. 0, 25, 50, 75, or 100% coverage. Initial substrate measures included measuring the x-axis of 10 to 15 stones that represented the specific reach of interest. On sampled streams, 100 substrata and respective embeddedness (quarter system as above for % canopy cover) values, and water depth were measured from randomly chosen locations within the stream section being analyzed. Specific conductance was measured in the field using an Orion (model 126) conductivity meter standarized to $20^{o}C$. Field pH was measured with either an Orion (model SA250) or Schott (model CG 837) pH meter calibrated each day of use with pH 7.0 and 4.0 or 10.0 buffers. Other measures of water chemistry, i.e. alkalinity, hardness, nitrate, ortho-phosphorus, were quantified in the laboratory using standard methods (APHA 1992). Nitrate and phosphorus absorptions were measured using a HACH meter (model DR2000) and HACH reagents. Water velocities for calculations of discharge were determined using a small Ott C-1 meter.

Periphyton chlorophyll a and ash-free-dry-mass (AFDM)(n=5), and amount of benthic organic matter (BOM) also were quantified at each sampled site (Table 2). Benthic organic matter was estimated from material obtained with the benthic macro-invertebrate samples (see below). Following removal of macroinvertebrates, organic matter was determined by drying the sample at 60 ^{o}C for at least 48 h, weighing, ashing at 550 ^{o}C for 2 h, rehydrating, redrying for at least 24 h, and reweighing. The difference in dry weights is the quantity of organic matter (as AFDM) for that sample.

Table 2. Summary of variables, sampling methods, and analytical procedures used in the study.

Variable	Type*	Sampling Method	Analytical Method	Reference
A. Physical				
Temperature	P	Digital thermometer	Direct observation	
Substratum Size	R	Measure x-axis of 100 randomly selected substrata	Calculate mean substratum size	Leopold 1970.
Substratum Embed-dedness	R	Visual estimation on 100 randomly selected substrata	Calculate mean substratum embededness	Platts et al. 1983.
Stream Width	T	Measure bank-full width using a nylon meter tape	Calculate mean stream width	Buchanan and Somers 1969.
Stream Depth	R	Measure water depth at the 100 randomly choosen substrata	Calculate mean water depth	
Discharge	T	Velocity/depth profile Velocity measured with a small C-1 Ott meter	Q=WxDxV; where Q=discharge, W=width, D=depth, and V=vel	Bovee and Milhous 1978.
B. Chemical				
Conductivity	P	Field measurement	Temperature comp-ensated meter	APHA 1992.
pH	P	Field measurement	Digital meter	APHA 1992.

* P=point measure; T=transect across stream; R=random throughout a defined reach.

Table 2 (cont.).

Variable	Type*	Sampling Method	Analytical Method	Reference
Alkalinity	P	Single water sample	Titration	Talling 1973, APHA 1992.
Hardness	P	Single water sample	EDTA titration	APHA 1992.
Nitrate	P	Single water sample	HACH meter	APHA 1992.
Phosphorus	P	Single water sample	HACH meter Measured as ortho-P	APHA 1992.
C. Biological				
Fish	R	Three passes with a backpack electrofisher through a measured reach of stream	Measure length, weight, and identify fish to species	Chandler and Maret 1993.
Invertebrates	R	Collect 5 samples using a Hess Sampler	Remove invertebrates, identify, enumerate, and analyze community properties	Platts et al. 1983, Merritt and Cummins 1984, Clark and Maret 1993.
Periphyton	R	Collect samples from 5 individual substrata	Acetone or Methanol extraction	Robinson and Minshall 1986.
Benthic Organic Matter	R	Recovered from Hess samples	Determine AFDM	Platts et al. 1983.

* P=point measure; T=transect across stream; R=random throughout a defined reach.

Periphyton was collected by scraping a known area from the surface of a stone and transfering the material onto a Whatman GF/F glass-fiber filter (see Robinson and Minshall 1986). Upon filtering, the material was kept frozen at -25°C until analysis in the laboratory for chlorophyll a and AFDM. Initially, samples were ground in reagent-grade acetone using a Brinkmann tissue homogenizer (Model PT 10/35). Chlorophyll a was extracted in reagent-grade acetone and quantified using a Gilford Model 2600 spectrophotometer (APHA 1992). Samples from 1993 were extracted in 100% methanol; methanol extraction eliminates the need to grind samples (Holm-Hansen and Riemann 1978). Although both extraction media result in similar extraction efficiencies, an experiment was conducted to compare chlorophyll a concentrations from samples using both media. Here, chlorophyll a was extracted from samples in acetone or methanol and quantified as above. The results of the experiment indicated no difference between the methanol and acetone methods ($p=0.76$, independent samples t-test, $n=20$). Periphyton AFDM of each sample was determined as described above for BOM using the remaining material from chlorophyll a analysis.

Field Collection for Macroinvertebrates and Fish

Qualitative and quantitative collection techniques were used for sampling macroinvertebrates depending on the year of study. In 1990, qualitative sampling was conducted at all selected sites and additional quantitative samples collected at five of these sites (Robinson and Minshall 1991). In 1991 and 1993, quantitative sampling was completed at all selected sites and additional qualitative samples collected in 1991 at ten of these sites. Habitat evaluation/assessment, and the field sampling for macroinvertebrates and fish generally required ca. 10 person-hours (e.g., 4-5 crew members for 2 h) per site, and only two sites typically were completed in one day because of the remote locations of sites.

Qualitative sampling followed protocols III and V of the Rapid Bioassessment Protocols recommended by the US Environmental Protection Agency (Plafkin et al. 1989, also see Resh and Jackson 1993). However, no separate "leaf pack" (coarse particulate organic matter/shredder) samples were collected because of the paucity of this material in the streams at the time of sampling (mid-summer). The rarity of leaf packs during a significant portion of the ice-free period indicates that this metric is of little value in these ecoregions, unless collections are made in mid- to late autumn (the period of leaf fall).

Benthic macroinvertebrates were qualitatively collected from riffle/run habitats using a metal-framed net (1-mm mesh in 1990 and 500-μm mesh in 1991 and 1993, 30cm high x 60cm wide x 100cm long) affixed to a "D"-style shovel handle. A 3-minute sample was proportioned among riffle and run habitats along a 150m length of stream. The material in the net was stored in labeled Whirl-pac^{tm} bags and preserved with 10% formalin. The material was transferred into 70% ETOH in the laboratory for sample storage. Quantitative benthic samples were collected at five riffle/run habitats using a modified Hess net (250-μm mesh) (Waters and Knapp 1961). Quantitative sampling followed the methodology described in Platts et al. (1983).

Fish were collected using a gas-powered Cofelt Model BP-6 or Smith-Root Model 15A backpack electrofisher (110 or 220 AC voltage) downstream from the benthic macroinvertebrate sample section. All sites had at least one pass made with the electrofisher along a maximum 100-m reach of stream encompassing a minimum of two riffles/runs and two pools. The actual distance electrofished was tape-measured. Blocknets were installed below and above each section prior to electrofishing. Three passes were completed at a number of sites for quantitative estimates of fish abundance (Zippin 3-step method; Platts et al. 1983). Fish were retained in insulated containers holding fresh stream water until processed. The fish from each pass were identified, counted, weighed, and noted for any external anomalies. A specimen of each species from each study stream was preserved with formalin and retained for reference and verification of field identifications. All remaining captured fish at a site were released. Voucher specimens were deposited in the Orma J. Smith Museum of Natural History, Albertson College of Idaho, Caldwell, Idaho.

Laboratory Processing of Macroinvertebrate Samples

In the laboratory, a 300-count sample of macroinvertebrates was systematically hand-picked from each qualitative sample for metric analysis. In 1990, all macroinvertebrates were removed from each quantitative sample. In 1991 and 1993, the five quantitative samples from a site were combined and a minimum of 300 organisms were systematically hand-picked from the composited sample. To maintain the quantitative nature of the Hess sample, the composite sample was placed in a white enamel pan (18cm x 29cm) marked off into twelve equal compartments or cells. All macroinvertebrates were removed from randomly selected cells until 300 or more organisms were removed. For example, a cell was completely picked of organisms regardless of whether 300 organisms were removed before completing the cell. Values of hand-picked specimens were then multiplied by the appropriate constant, i.e. (number of organisms) x (12/no. of cells completed), for estimates of total abundance. These data also were used for estimates of total macroinvertebrate densities. All picked macroinvertebrates from qualitative or quantitative samples were identified to lowest feasible taxonomic unit (usually genus) and enumerated (Appendix D). Specimens of all macroinvertebrate taxa collected were retained for voucher collections and housed at the Stream Ecology Center of Idaho State University, Pocatello; the Idaho Department of Health and Welfare, Bureau of Laboratories, Boise; and the Orma J. Smith Museum of Natural History, Albertson College of Idaho, Caldwell.

Data Analysis and Metric Development

Multiple discriminant analysis (MDA) and principal components analysis (PCA) were completed using habitat measures (Tables 3, 4) and the qualitative habitat assessment categories (Tables 5, 6) in order to distinguish between ecoregions and among stream types (Tabachnick and Fidell 1989). Analyses were completed on an HP-Vectra (model RS/20) PC using the Statistica software program (Statsoft 1990). Both analyses were found effective in determining important habitat characteristics and indicated the need to incorporate both qualitative and quantitative measures to describe stream habitat conditions. Selected quantitative measures were scored by proportional scaling of measured values over an arbitrary range of 0 to 15 (maximum score per measure equaled 15) to make them comparable with the habitat assessment categories. These scores for each measure (category) were summed for each site for an overall habitat score (e.g., Tables 7, 8).

Biotic metrics were calculated from the macroinvertebrate and fish data from each site as described in Winget and Magnum (1979), Platts et al. (1983), Plafkin et al. (1989), Fisher (1989), Chandler and Maret (1993), and Clark and Maret (1993). Eighteen metrics were calculated for benthic macroinvertebrates: ratio of Ephemeroptera, Plecoptera, and Trichoptera (EPT) abundance to Chironomidae (CH) and Oligochaeta (O) abundance (EPT/CH+O); species richness; EPT richness; Hilsenhoff Biotic Index (HBI); Biotic Condition Index (BCI); ratio of EPT/Ch; % dominance; Shannon's diversity index (H'); Simpson's dominance index (C); ratio of Scrapers to Filterers (S/F ratio); ratio of Shredders to Total macroinvertebrate abundance; macroinvertebrate density; % Scrapers; % Filterers; % Shredders; % EPT taxa; % CH+O; and % Chironomidae (Table 9). The HBI used an assumed scale from 0-10 (Hilsenhoff 1988), and regional tolerance values from Clark and Maret (1993).

Fifteen metrics were calculated for fish: species richness; number of native species; number of introduced species; number of Salmonidae species; number of benthic insectivore species; number

Table 3. Summary of habitat measures recorded for NBR study sites.

STATION	#	DATE	ELEV. (m)	WIDTH/ DEPTH RATIO	MEAN WIDTH (m)	AREA SHOCKED (m2)	% COVER	AFDM (mg/cm2)	CHL-a (mg/cm2)	Q (m3/s)	TEMP. (C)	SPEC. COND. (umhos)	ALKA (mg/L) (CaCO3)	T. Hard (mg/L) (CaCO3)	pH	NO3 (mg/L)	PO4 (mg/L)	SUBSRT. AVG.	EMBED. AVG. (%)	SLOPE	BOM AFDM (g/m^2)
Northern Basin and Range - Lowland Sites																					
Pearl	68	1993	1800	12.4	2.41	181	50	0.4	0.5	0.35	11.8	110	46	70	8.3	0.07	0.02	19	39	1.5	44.9
Pebble	85	1993	2000	15.8	4.90	450	33	78.0	24.2	0.77	6.6	59	30	56	8.3	0.10	0.05	14	23	2.0	504.8
Eight Mile	94	1993	1800	28.6	4.96	496	80	12.3	7.2	2.55	7.5	217	56	102	8.3	0.09	0.10	6	44	3.0	29.2
Angus (low)	60	1993	1760	7.7	3.04	252	0	49.0	24.7	0.1	14.2	185	99	162	8.3	0.01	0.14	4.6	31	1.5	835.7
Slug	71	1993	1800	16.4	4.86	486	20	36.0	4.2	0.20	15.6	225	129	183	8.4	0.08	0.04	8	57	1.5	303.7
Crow	65	1993	2040	14.7	5.10	204	0	2.0	1.2	0.98	18.6	305	131	193	8.5	0.07	0.13	5	69	1.5	109.7
Clyde	64	1993	1885	33.0	5.96	238	55	0.3	1.0	0.37	14.7	92	38	74	7.9	0.07	0.03	12	43	2.5	7.8
Up Portneuf	69	1993	1680	19.0	4.30	301	0	11.0	1.8	0.20	21.4	172	152	298	8.5	0.08	0.06	12	39	2.5	107.8
Lanes	67	1993	2000	13.5	5.60	392	0	1.0	0.8	1.32	17.9	297	127	176	8.3	0.08	0.07	29	42	1.2	43.6
Lake Fork	18	1990	1634	10.2	1.30	39	0	0.1	9.8	0.05	10.2	234	229	246	8.3			2	50	0.8	7.8
Chippy	62	1993	1500	9.0	1.24	124	0	16.0	11.9	0.27	18.2	309	120	176	8.5	0.08	0.04	2	81	1.5	226.2
Station	19	1990	1636	19.2	4.50	293	0	29.0	273.8	0.14	10.2	281	248	294	8.0			1	50	1.0	11.0
SF Mink	49	1991	1933	19.8	2.60	30	0	9.9	55.6	0.13	17.5	417	216	218	8.6	0.00	0.44	6	42	0.5	10.4
Cassia	28	1990	1500	23.2	6.70	402	7	2.0	41.6	0.45	13.5	115	81	106	8.3			5	50	0.5	21.3
Trapper	31	1990	1539	26.4	6.60	198	25	10.0	72.0	0.34	14.5	151	119	161	8.5			8	50	1.0	14.9
Angus (up)	61	1993	1760	6.0	2.10	105	2	29.0	7.1	0.25	16.0	185	99	162	8.3	0.08	0.05	2	78	1.5	42.6
Wright	73	1993	1560	11.1	2.24	157	0	1.0	0.6	0.23	12.7	321	109	193	8.6	0.04	0.09	7	36	0.5	140.1
Wolverine	50	1991	1833	10.3	2.13	120	10	10.9	8.3	0.19	14.6	497	211	230	8.8	0.13	0.06	10	50	1.5	9.8
Rock (Holbrook)	86	1993	1600	23.6	2.86	200	20	8.0	2.0	0.04	18.5	547	111	242	8.7	0.07	0.04	5	55	0.8	6.5
Kelsaw	66	1993	2400	8.6	1.00	100	25	6.0	0.5	0.04	12.3	549	101	183	8.7	0.06	0.20	3	46	2.5	256.6
Northern Basin and Range - Upland Sites																					
Toponce	90	1993	1880	14.0	3.6	162	60	40.0	16.2	0.39	12.0	28	12	25	8.5	0.07	0.07	15	29	2.0	47.5
Bell Marsh	93	1993	1750	15.4	4.2	273	60	0.6	2.8	0.53	9.8	98	38	56	8.2	0.07	0.05	19	32	4.5	76.9
Green	1	1990	1772	15.9	2.8	280	65	0.1	2.2	0.12	10.0	22	10	42	7.3	0.06	0.02	28	43	12.0	54.6
Stinson	2	1990	1848	13.1	2.2	66	80	0.1	3.3	0.10	13.6	27	14	40	8.0			6	32	9.0	23.5
Mink	36	1991	1647	37.3	6.0	240	20	149.9	1.9	0.16	15.0	317	165	200	8.7	0.24	0.06	19	36	6.0	13.4
Cottonwood	5	1990	1500	21.8	2.9	145	30	0.1	1.8	0.10	14.3	59	35	40	7.9			16	32	1.0	81.2
3rd Fork	8	1990	1575	29.4	5.4	189	50	1.0	0.1	0.12	9.0	78	68	90	7.6			21	31	2.0	25.1
Bloomington	35	1991	1891	17.4	4.1	202	50	3.5	1.3	0.38	6.3	391	166	167	8.6	0.08	0.07	22	39	7.0	18.3
Trapper	3	1990	1612	18.5	3.7	130	1	1.0	10.2	0.36	16.7	151	109	139	8.0			6	27	2.0	23.7
Green(Inkom)	79	1993	1750	12.5	2.5	305	60	1.0	3.4	0.28	9.4	94	19	42	8.1	0.07	0.05	14	43	4.3	2.1
Walker	92	1993	1750	12.9	1.5	112	60	0.5	0.2	0.11	9.5	103	60	95	8.3	0.08	0.05	11	22	2.5	47
WF Mink	37	1991	1800	17.1	2.3	30	60	9.7	16.5	0.12	16.2	391	196	190	8.7	0.01	0.13	4	59	4.5	15.8
lowland mean			1783.0	16.4	3.7	238.4	16.4	15.6	27.4	0.45	14.3	263	123	176	8.4	0.07	0.10	8	49	1.5	136.7
lowland stddev			216.3	7.3	1.8	139.9	22.2	19.4	59.8	0.58	3.8	142	61	67	0.2	0.03	0.10	7	14	0.7	204.9
lowland stderr			49.6	1.7	0.4	32.1	5.1	4.5	13.7	0.13	0.9	33	14	15	0.0	0.01	0.02	2	3	0.2	47.0
upland mean			1731.3	18.8	3.4	177.8	49.7	17.3	5.0	0.23	11.8	147	74	94	8.2	0.09	0.06	15	35	4.7	35.7
upland stddev			118.3	7.2	1.3	82.9	21.1	41.4	5.7	0.14	3.2	133	65	61	0.4	0.06	0.03	7	9	3.2	24.4
upland stderr			35.6	2.2	0.4	25.0	6.3	12.5	1.7	0.04	1.0	40	20	19	0.1	0.02	0.01	2	3	1.0	7.3

Table 4. Summary of habitat measures recorded for SRP study sites.

STATION	#	DATE	ELEV. (m)	WIDTH/ DEPTH RATIO	MEAN WIDTH (m)	AREA SHOCKED (m2)	% COVER	AFDM (mg/cm2)	CHL-a (mg/cm2)	Q (m3/s)	TEMP. (C)	SPEC. COND. (umhos)	ALKA (mg/L) (CaCO3)	T. Hard (mg/L) (CaCO3)	pH	NO3 (mg/L)	PO4 (mg/L)	SUBSRT. AVG	EMBED AVG (%)	SLOPE	BOM AFDM (g/m^2)
Snake River Plain - Lowland Sites																					
Little Jack	15	1990	1072	31.1	3.3	99	65	1.0	12.1	0.05	18.8	125	57	50	7.9			8	34	0.8	56.3
Current	46	1991	1767	17.6	3.1	166	25	102.1	3.5	0.09	17.2	28	11	13	7.5	0.12	0.44	16	19	3.5	1.9
Big Jack	16	1990	1333	22.9	4.4	110	50	2.0	63.8	0.15	18.0	125	67	60	8.9			18	23	1.0	30.8
Cold Springs	45	1991	1293	12.3	3.0	90	50	58.3	1.5	0.15	10.2	55	27	23	7.8	0.09	0.25	7	5	4.0	24.3
Duncan	47	1991	1620	16.6	1.7	52	90	11.2	29.5	0.01	10.3	106	50	43	8.0	0.10	0.28	12	19	1.5	28.6
Big Willow	44	1991	933	39.5	7.4	352	90	11.3	36.3	0.22	17.6	174	84	67	8.7	0.11	0.18	18	21	1.5	8.7
Cottonwood	17	1990	1455	21.0	2.7	40	99	1.0	20.8	0.04	16.0	210	41	44	7.9			17	33	0.8	34.3
Willow	72	1993	1530	45.0	7.1	710	75	0.8	15.7	0.17	14.2	194	74	112	8.1	0.09	0.03	8	75	1.0	38.1
Clover	63	1993	1500	32.0	2.2	220	50	0.5	0.3	0.01	12.6	96	36	56	7.7	0.02	0.10	7	76	1.5	30.6
Spring	48	1991	1147	17.3	2.0	85	70	244.7	26.6	0.01	14.3	121	57	72	7.9	0.09	0.35	8	36	3.0	31.2
Big Jack	27	1990	1242	22.9	5.8	319	5	2.0	84.5	0.16	18.0	153	66	57	6.4			18	30	1.0	12.0
Sheep	26	1990	1467	20.2	6.6	198	3	4.0	28.4	0.59	14.7	72	57	68	7.9			11	37	2.0	19.6
Mary's	29	1990	1730	23.5	4.9	245	2	2.0	30.5	0.06	15.7	75	54	78	7.3			17	27	1.0	60.1
Rock (Magic)	53	1991	1716	13.7	2.4	202	5	199.6	3.6	0.10	17.6	286	126	131	8.3	0.22	0.16	7	27	4.0	18.8
Shoshone	32	1990	1636	21.8	8.3	208	0	0.1	4.7	0.69	16.0	92	63	82	7.1			9	37	1.0	25.2
Deep	52	1991	1727	21.5	5.7	597	0	7.0	18.3	0.13	18.6	51	24	19	7.6	0.06	0.23	3	59	1.0	9.2
Shoofly	70	1993	1200	24.0	2.8	284	50	0.7	0.9	0.06	14.4	91	44	35	7.8	0.04	0.08	11	51	1.0	304.7
Camas	51	1991	1640	31.8	9.1	683	0	7.9	2.6	0.64	25.4	108	66	45	8.6	0.11	0.46	0.1	100	0.5	0.9
Snake River Plain - Upland Sites																					
Buck	4	1990	1590	14.3	3.5	88	50	1.0	35.2	0.03	15.2	137	105	121				10.5	29	9.0	17.1
Soldier	88	1993	2000	32.0	5.2	464	75	0.8	8.7	0.28	9.5	68	26	49	8.1	0.06	0.07	23.2	40	4.0	22.0
Ramey	42	1991	640	10.5	2.2	109	60	2.1	17.9	0.17	7.5	95	25	27	8.4	0.07	0.06	24.1	13	14.0	25.1
Coyote	43	1991	2403	19.8	2.2	109	75	1.2	2.8	0.07	12.0	68	36	35	8.1	0.04	0.01	13.9	54	4.0	11.0
Cherry	40	1991	2393	18.9	1.8	91	45	2.1	3.7	0.08	14.0	142	67	75	8.6	0.03	0.01	14.2	21	3.5	8.7
Squaw	89	1993	2300	21.7	3.3	199	75	0.7	0.7	0.16	8.6	207	58	91	8.5	0.05	0.03	20.6	31	4.0	73.7
Bear	41	1991	717	17.9	2.6	90	90	2.0	7.8	0.13	10.5	82	12	15	8.0	0.03	0.04	13.9	42	0.5	10.7
SF Soldier	39	1991	2020	22.9	4.6	270	75	2.7	2.0	0.24	7.2	39	10	11	7.9	0.07	0.09	19.6	22	4.0	2.9
Timber	38	1991	2546	18.9	2.9	208	60	1.7	3.8	0.05	9.5	160	46	40	8.4	0.03	0.11	16.9	26	3.0	10.3
Iron	80	1993	2500	33.3	4.0	404	75	0.4	1.8	0.12	7.3	64	44	36	8.5	0.04	0.69	15.4	45	4.0	8.1
lowland mean			1445	24.2	4.6	259	41	36.4	21.3	0.19	16.1	120	56	59	7.9	0.10	0.23	10.8	39	1.7	40.9
lowland stddev			245	8.4	2.3	201	35	70.7	22.2	0.21	3.4	62	25	29	0.6	0.05	0.14	5.3	24	1.1	65.9
lowland stderr			58	2.0	0.5	47	8	16.7	5.2	0.05	0.8	15	6	7	0.1	0.01	0.03	1.2	6	0.3	15.5
upland mean			1911	21.0	3.2	203	68	1.5	8.4	0.13	10.1	106	43	50	8.3	0.05	0.12	17.2	32	5.0	19.0
upland stddev			674	6.7	1.0	130	13	0.7	10.1	0.08	2.7	50	27	33	0.2	0.02	0.20	4.2	12	3.6	19.3
upland stderr			213	2.1	0.3	41	4	0.2	3.2	0.02	0.8	16	9	11	0.1	0.00	0.06	1.3	4	1.1	6.1

Table 5. Habitat assessment scores for streams sampled in the NBR ecoregion.

STATION	#	DATE	SUBSTRATE COVER	EMBED	FLOW VELOCITY	CANOPY COVER	CHANNEL ALTERATION	BOTTOM SCOUR	POOL RIFFLE	WIDTH DEPTH	BANK STABILITY	BANK VEG.	STREAM COVER	RIPARIAN WIDTH	TOTAL SCORE
Northern Basin and Range - Lowland Sites															
Pearl	68	1993	20	20	15	19	15	13	13	15	10	10	10	10	170
Pebble	85	1993	20	20	18	16	14	15	14	15	8	9	9	10	168
Eight Mile	94	1993	18	19	16	19	13	14	11	14	10	10	10	10	164
Angus (low)	60	1993	19	20	18	6	14	14	15	15	8	9	6	10	154
Slug	71	1993	17	20	16	5	20	5	11	14	8	10	7	9	142
Crow	65	1993	16	19	19	4	11	9	15	15	8	10	5	10	141
Clyde	64	1993	17	12	18	19	12	10	13	14	5	4	8	8	140
Up Portneuf	69	1993	18	19	12	8	12	12	11	15	8	9	7	9	140
Lanes	67	1993	18	18	8	0	11	14	11	14	6	9	5	9	123
Lake Fork	18	1990	15	18	10	0	15	14	11	3	9	10	5	6	116
Chippy	62	1993	8	18	15	0	13	11	13	14	2	9	4	9	116
Station	19	1990	15	18	10	0	11	9	10	12	5	8	6	7	111
SF Mink	49	1991	16	17	12	13	6	3	8	10	1	8	7	7	108
Cassia	28	1990	15	11	17	5	6	6	13	3	7	9	8	6	106
Trapper	31	1990	13	1	18	15	1	9	8	11	3	9	4	7	99
Angus (up)	61	1993	5	7	9	3	7	7	12	11	5	5	3	8	82
Wright	73	1993	13	6	5	0	5	6	5	5	3	5	4	1	58
Wolverine	50	1991	6	12	6	5	4	3	5	5	1	5	3	1	56
Rock(Holbrook)	86	1993	7	6	3	5	2	1	5	2	1	4	4	1	41
Kelsaw	66	1993	6	6	3	11	0	2	1	2	0	4	4	0	39
Northern Basin and Range - Upland Sites															
Toponce	90	1993	20	20	18	20	19	15	14	13	9	10	10	9	177
Bell Marsh	93	1993	18	20	17	20	15	14	15	14	9	10	10	10	172
Green	1	1990	20	20	18	20	15	15	13	12	10	10	9	10	172
Stinson	2	1990	20	20	18	20	15	15	13	12	10	10	9	10	172
Mink	36	1991	20	20	18	17	13	14	14	14	10	9	8	8	165
Cottonwood	5	1990	18	18	18	16	15	15	14	12	10	10	10	8	164
3rd Fork	8	1990	18	18	18	19	15	14	14	15	8	9	9	6	163
Bloomington	35	1991	20	20	15	20	14	14	12	14	10	7	8	8	162
Trapper	3	1990	19	20	19	11	15	11	13	11	10	10	8	8	155
Green(Inkom)	79	1993	17	19	16	20	11	7	10	13	5	7	10	9	144
Walker	92	1993	15	19	16	17	9	14	10	15	2	7	9	10	143
WF Mink	37	1991	15	15	10	18	10	11	12	14	8	10	10	9	142

Table 6. Habitat assessment scores for streams sampled in the SRP ecoregion.

STATION	#	DATE	SUBSTRATE COVER	EMBED	FLOW VELOCITY	CANOPY COVER	CHANNEL ALTERATION	BOTTOM SCOUR	POOL RIFFLE	WIDTH DEPTH	BANK STABILITY	BANK VEG.	STREAM COVER	RIPARIAN WIDTH	TOTAL SCORE
Snake River Plain - Lowland Sites															
Little Jack	15	1990	18	20	16	20	15	15	15	14	10	10	10	10	173
Current	46	1991	18	18	20	17	14	13	15	15	10	10	10	8	168
Big Jack	16	1990	20	14	18	18	15	11	15	14	10	10	10	9	164
Cold Springs	45	1991	17	19	12	19	14	12	13	14	9	10	9	10	158
Duncan	47	1991	18	18	13	16	15	12	8	9	10	10	10	9	148
Big Willow	44	1991	20	14	13	20	11	9	12	11	10	10	9	8	147
Cottonwood	17	1990	18	10	14	10	15	15	10	14	10	10	10	8	144
Willow	72	1993	16	11	20	16	13	7	12	14	9	7	8	5	138
Clover	63	1993	17	13	6	20	15	10	8	12	6	8	10	5	130
Spring	48	1991	13	9	7	19	15	11	8	10	10	10	10	8	130
Big Jack	27	1990	10	11	15	3	11	11	13	14	7	10	5	1	111
Sheep	26	1990	17	17	19	2	7	9	12	3	1	8	9	1	105
Mary's	29	1990	13	11	17	5	6	6	13	6	1	8	7	6	99
Rock (Magic)	53	1991	9	10	6	6	11	9	11	12	5	4	3	4	90
Shoshone	32	1990	8	3	8	0	10	10	6	3	4	10	4	3	69
Deep	52	1991	5	11	7	3	6	6	7	4	2	3	4	8	66
Shoofly	70	1993	5	4	2	6	2	5	2	8	5	2	5	2	48
Camas	51	1991	0	6	1	0	1	1	4	2	3	3	3	3	27
Snake River Plain - Upland Sites															
Buck	4	1990	20	18	20	20	15	14	14	15	10	10	8	7	171
Soldier	88	1993	20	19	13	19	20	13	11	10	10	9	10	9	163
Ramey	42	1991	20	20	13	18	15	13	13	15	10	9	8	8	162
Coyote	43	1991	18	18	15	19	12	12	15	15	10	10	9	8	161
Cherry	40	1991	19	20	14	19	14	14	11	15	10	10	9	6	161
Squaw	89	1993	16	19	18	18	15	14	14	13	9	9	5	6	156
Bear	41	1991	16	18	19	17	12	12	14	14	10	9	6	7	154
SF Soldier	39	1991	13	16	13	20	14	11	12	15	10	10	9	10	153
Timber	38	1991	19	15	13	20	13	10	13	14	9	9	8	8	151
Iron	80	1993	20	19	13	9	11	5	9	13	9	10	9	8	135

Table 7. Assignment of habitat assessment scores (SC) for streams of NBR ecoregions of Idaho based on results from PCA.

STATION	#	TEMP. (C)	SC	SPECIFIC COND. (umhos)	SC	ALKALINITY (mg/L) (CaCO3)	SC	T.HARD (mg/L) (CaCO3)	SC	SUBSRT. COVER	EMBED	FLOW VELOCITY	CHANNEL ALTERATION	BOTTOM SCOUR	POOL RIFFLE	BANK VEG	STREAM COVER	TOTAL SCORE
Northern Basin and Range - Lowland Sites																		
Pebble	85	6.6	15	59	15	30	15	56	15	20	20	18	14	15	14	9	9	179
Pearl	68	11.8	10	110	10	46	10	70	15	20	20	15	15	13	13	10	10	161
Eight Mile	94	7.5	15	217	5	56	10	102	5	18	19	16	13	14	11	10	10	146
Clyde	64	14.7	5	92	10	38	15	74	15	17	12	18	12	10	13	4	8	139
Angus (low)	60	14.2	5	185	5	99	5	162	5	19	20	18	14	14	15	9	6	135
Slug	71	15.6	5	225	5	129	5	183	5	17	20	16	20	5	11	10	7	126
Crow	65	18.6	5	305	5	131	5	193	5	16	19	19	11	9	15	10	5	124
Lake Fork	18	10.2	10	234	5	229	5	246	5	15	18	10	15	14	11	10	5	123
Up Portneuf	69	21.4	5	172	5	152	5	298	5	18	19	12	12	12	11	9	7	120
Lanes	67	17.9	5	297	5	127	5	176	5	18	18	8	11	14	11	9	5	114
Station	19	10.2	10	281	5	248	5	294	5	15	18	10	11	9	10	8	6	112
Chippy	62	18.2	5	309	5	120	5	176	5	8	18	15	13	11	13	9	4	111
Cassia	28	13.5	5	115	10	81	5	106	5	15	11	17	6	6	13	9	8	110
SF Mink	49	17.5	5	417	5	216	5	218	5	16	17	12	6	3	8	8	7	97
Trapper	31	14.5	5	151	10	119	5	161	5	13	1	18	1	9	8	9	4	88
Angus (up)	61	16.0	5	185	5	99	5	162	5	5	7	9	7	7	12	5	3	75
Wright	73	12.7	5	321	5	109	5	193	5	13	6	5	5	6	5	5	4	69
Wolverine	50	14.6	5	497	5	211	5	230	5	6	12	6	4	3	5	5	3	64
Rock(Holbrook)	86	18.5	5	547	5	111	5	242	5	7	6	3	2	1	5	4	4	52
Kelsaw	66	12.3	5	549	5	101	5	183	5	6	6	3	0	2	1	4	4	46
Northern Basin and Range - Upland Sites																		
Toponce	90	12.0	10	28	15	12	15	25	15	20	20	18	19	15	14	10	10	181
Green	1	10.0	15	22	15	10	15	42	15	20	20	18	15	15	13	10	9	180
Stinson	2	13.6	5	27	15	14	15	40	15	20	20	18	15	15	13	10	9	170
Bell Marsh	93	9.8	15	98	10	38	15	56	10	18	20	17	15	14	15	10	10	169
Cottonwood	5	14.3	5	59	15	35	15	40	15	18	18	18	15	15	14	10	10	168
3rd Fork	8	9.0	15	78	15	68	10	90	10	18	18	18	15	14	14	9	9	165
Green(Inkom)	79	9.4	15	94	10	19	15	42	15	17	19	16	11	7	10	7	10	152
Bloomington	35	6.3	15	391	5	166	5	167	5	20	20	15	14	14	12	7	8	140
Trapper	3	16.7	5	151	10	109	5	139	5	19	20	19	15	11	13	10	8	140
Walker	92	9.5	15	103	10	60	10	95	5	15	19	16	9	14	10	7	9	139
Mink	36	15.0	5	317	5	165	5	200	5	20	20	18	13	14	14	9	8	136
WF Mink	37	16.2	5	391	5	196	5	190	5	15	15	10	10	11	12	10	10	113
Upland Mean (all sites)		11.1		128		60		74										
stderr		0.7		23		11		12										
mean-90%CL		9.9		89		40		54										
mean+90%CL		12.2		167		80		94										
SCORE																		
15		<10		<90		<40		<54										
10		10-12		90-167		40-80		54-94										
5		>12		>167		>80		>94										

Table 8. Assignment of habitat assessment scores (SC) for streams of SRP ecoregions of Idaho based on results from PCA.

STATION	#	TEMP. (C)	SC	SPECIFIC COND. (umhos)	SC	ALKALINITY (mg/L) (CaCO3)	SC	T. HARD (mg/L) (CaCO3)	SC	SUBSRT. COVER	EMBED	FLOW VELOCITY	CHANNEL ALTERATION	BOTTOM SCOUR	POOL RIFFLE	BANK VEG	STREAM COVER	TOTAL SCORE
Snake River - Lowland Sites																		
Current	46	17.2	5	28	15	11	15	13	15	18	18	20	14	13	15	10	10	168
Cold Springs	45	10.2	10	55	15	27	15	23	15	17	19	12	14	12	13	10	9	161
Little Jack	15	18.8	5	125	10	57	10	50	15	18	20	16	15	15	15	10	10	159
Duncan	47	10.3	10	106	10	50	10	43	15	18	18	13	15	12	8	10	10	149
Big Jack	16	18.0	5	125	10	67	10	60	10	20	14	18	15	11	15	10	10	148
Sheep	26	14.7	5	72	15	57	10	68	10	17	17	19	7	9	12	8	9	138
Cottonwood	17	16.0	5	210	5	41	10	44	15	18	10	14	15	15	10	10	10	137
Clover	63	12.6	5	96	10	36	15	56	10	17	13	6	15	10	8	8	10	127
Big Willow	44	17.6	5	174	5	84	5	67	10	20	14	13	11	9	12	10	9	123
Big Jack	27	18.0	5	153	10	66	10	57	10	10	11	15	11	11	13	10	5	121
Mary's	29	15.7	5	75	15	54	10	78	10	13	11	17	6	6	13	8	7	121
Willow	72	14.2	5	194	5	74	10	112	5	16	11	20	13	7	12	7	8	119
Spring	48	14.3	5	121	10	57	10	72	10	13	9	7	15	11	8	10	10	118
Deep	52	18.6	5	51	15	24	15	19	15	5	11	7	6	6	7	3	4	99
Shoshone	32	16.0	5	92	10	63	10	82	10	8	3	8	10	10	6	10	4	94
Rock (Magic)	53	17.6	5	286	5	126	5	131	5	9	10	6	11	9	11	4	3	83
Shoofly	70	14.4	5	91	10	44	10	35	15	5	4	2	2	5	2	2	5	67
Camas	51	25.4	5	108	10	66	10	45	15	0	6	1	1	1	4	3	3	59
Snake River Plain - Upland Sites																		
Soldier	88	9.5	15	68	15	26	15	49	15	20	19	13	20	13	11	9	10	175
Ramey	42	7.5	15	95	10	25	15	27	15	20	20	13	15	13	13	9	8	166
Coyote	43	12.0	10	68	15	36	15	35	15	18	18	15	12	12	15	10	9	164
Bear	41	10.5	10	82	15	12	15	15	15	16	18	19	12	12	14	9	6	161
SF Soldier	39	7.2	15	39	15	10	15	11	15	13	16	13	14	11	12	10	9	158
Iron	80	7.3	15	64	15	44	10	36	15	20	19	13	11	5	9	10	9	151
Squaw	89	8.6	15	207	5	58	10	91	10	16	19	18	15	14	14	9	5	150
Timber	38	9.5	15	160	10	46	10	40	15	19	15	13	13	10	13	9	8	150
Cherry	40	14.0	5	142	10	67	10	75	10	19	20	14	14	14	11	10	9	146
Buck	4	15.2	5	137	10	105	5	121	5	20	18	20	15	14	14	10	8	144
Upland Mean (all sites)		11.1		128.2		60.0		73.9										
stderr		0.7		22.5		11.4		11.8										
mean-90%CL		9.9		89.5		40.4		53.7										
mean+90%CL		12.2		167.0		79.7		94.1										
SCORE																		
15		<10		<90		<40		<54										
10		10-12		90-167		40-80		54-94										
5		>12		>167		>80		>94										

Table 9. Definition of macroinvertebrate metrics used in analyses.

EPT/Chironomidae+Oligochaeta Ratio- Based on the relative abundances of Ephemeroptera, Plecoptera, Tricoptera to Chironomidae and Oligichaeta to assess community health. A disproportionate number of the relatively pollution tolerant Chironomidae and Oligichaetae suggests degraded habitat conditions.

Species Richness- Reflects health of the community through a measure of the number of distinct species (or taxa) present. Typically, a higher number of taxa suggests good habitat quality.

EPT Richness- The total number of distinct taxa in the orders Ephemeroptera, Plecoptera, Tricoptera. These groups are generally sensitive to pollution, with a low EPT Richness indicating degraded habitat quality.

HBI- Hilsenhoff's Biotic Index detects organic pollution stress in communities inhabiting stream riffles. HBI summarizes the pollution tolerance of each taxa, based on the abundance of respective taxa in the community, into a single value. Regional values for tolerance (Clark & Maret 1993) were used. Higher values typically indicate greater levels of organic pollution. $HBI=\Sigma x_i t_i/n$; where x_i=number of individuals of a taxon, t_i=tolerance value of taxon, and n=total number of individuals.

BCI- The Biotic Condition Index summarizes the pollution tolerance of each taxa in the community into a single value, but in contrast to HBI, it does not consider the relative abundance of the various taxa. The calculated value is then compared to a predicted value based on the stream's gradient, substrate, alkalinity, and sulfate concentrations. $BCI=CTQ_p/CTQ_a*100$, where CTQ_p=predicted community tolerance quotient, and CTQ_a=actual community tolerance quotient (Winget and Magnum 1979).

Table 9. (con't.)

EPT/Chironomidae Ratio- Uses the relative abundance of these indicator groups to assess community balance. A high number of tolerant Chironomidae indicates degraded habitat conditions.

% Dominance- A simple measure of a community's redundancy and evenness. The measure assumes that a highly redundant community (i.e., dominated by a single taxa) is impaired.

Diversity (H')- A diversity index based on based on the species richness and respective relative abundances. Greater diversity values generally suggest good habitat quality. $H'=\Sigma pi \mathrm{LOG} pi$.

Simpson's Index (C)- A diversity index that reflects dominance or evenness of an assemblage. $C=\Sigma pi^2$.

S/F Ratio- The ratio of scraper to filtering functional feeding groups. Generally, a high number of filtering type invertebrates reflect increased organic loading and poor habitat quality.

% Shredders- Measures the relative abundance of the shredding functional feeding group. A low number of shredders reflects poor or altered riparian conditions.

Density- The number of macroinvertebrates in a given area. Low benthic densities reflect degraded habitat conditions.

% Scrapers- A relative measure of the abundance of the scraping functional feeding group. A greater percentage of scrapers suggest good habitat quality.

% Filterers- A relative measure of the abundance of the filtering functional feeding group. A large percentage of filterers may indicate excessive sediment/organic load and consequently poor habitat quality.

Table 9. (cont.)

% EPT- The relative abundance of Ephemeropterans, Plecopterans, and Tricopterans in a stream. These groups are generally intolerant to pollution and used as indicator taxa.

% Chironomidae+Oligochaeta- A measure of the relative abundance of the generally pollution tolerant groups Chironomidae and Oligichaeta. A community with a high percentage of Chironomidae+Oligochaeta may indicate excessive erosion and/or sediment/organic load in the stream.

% Chironomidae- A measure of the relative abundance of the generally pollution tolerant group Chironomidae. A community with a high percentage of Chironomidae may indicate excessive erosion and sediment/organic load in the stream.

of intolerant species; % introduced species; % carnivores; % invertivores; % Salmonidae; total density; total biomass; Salmonidae density; Salmonidae biomass; and Salmonidae condition factor (Table 10). Fish Condition Index was calculated as: (weight in grams)/(total length^3 in cm)*(10^5). Fish tolerance, trophic guild, and native/introduced designations were determined from Chandler and Maret (1993).

Respective scores for metrics were determined using recommendations in Plafkin et al. (1989) and based on the 90% confidence limits about the mean absolute value for upland (reference) sites within each ecoregion. For example, a score of 5 (representing the optimal value for a metric) was assigned if the absolute value for that metric was greater than (or less than, if a low value indicated the optimal condition) the 90% confidence limit (CL) about the mean absolute value (i.e. mean ±90%CL). A score of 3 was assigned if the absolute value fell within the mean ±90%CL values, whereas a score of 1 was assigned for absolute values that were less than (or greater than, if a high value indicated the degraded state) the mean absolute value ±90%CL.

Important biotic metrics to distinguish between ecoregions and among stream types were determined separately for macroinvertebrates and fish using multiple discriminant analysis (MDA) and principal components analysis (PCA)(Statsoft 1991). Once important metrics were determined for macroinvertebrates or fish, metric criteria scores were summed for each site and regressed against respective habitat assessment scores. Additional regressions were completed for summed metric scores against habitat assessment scores by ecoregion. ANOVA was used to test for differences between the summed criteria metric scores among stream types and between ecoregions (Zar 1984). The post hoc Student Newman-Kuels (SNK) test was used to determine differences among means.

Table 10. Definitions for fish metrics.

Species Richness- The number of distinct species in a given stream. This measure indicates the relative health of the system through a measure of the variety of species found.

Number of Native Species- A measure of the degree to which the fish community is dominated by native species.

Number of Introduced Species- A measure of the degree to which the fish community is dominated by introduced or exotic species.

Number of Salmonidae- The number of the generally pollution intolerant family Salmonidae present in a stream. A high number of Salmonidae indicate good cold-water habitat.

Number of Benthic Insectivores- The number of fish present which feed on benthic insects. Low numbers of benthic insectivores indicate poor habitat quality and a depauperate food-base.

Number of Intolerant Species- The number of fish species present in a stream which are intolerant of organic pollution. A low number of intolerant species suggests organic pollution or poor habitat quality.

% Introduced Species- A relative measure of the number of introduced fish species in a stream. Higher numbers reflect greater anthropogenic influences.

% Carnivores- A relative measure of the number of carnivorous fish species in a stream. High numbers suggest good habitat quality and a healthy food-base.

% Invertivores- A relative measure of the number of obligate invertebrate feeding fish speceis. A low percentage of invertivores indicate an impaired invertebrate community.

Table 10. (cont.)

% Salmonidae- A relative measure of the number of Salmonids in a stream. High values represent good habitat conditions.

Total Density- The total number of fish in a given area of stream.

Total Biomass- The total biomass of fish in a given area of stream.

Salmonidae Density- The number of Salmonids in a given area of stream.

Salmonidae Biomass- The biomass of Salmonids in a given area of stream.

Salmonidae Condition Factor- A value reflecting the physiological health of the Salmonid population. Low values indicate poor habitat quality. Condition=w/l^3*10^5, where w=weight in grams, and l=total length in millimeters.

Inclusion of the Northern Rocky Mountain Ecoregion (NRM)

We evaluated the feasibility of incorporating Fisher's (1989) data on 136 relatively undisturbed Northern Rocky Mountain streams by assessing the aquatic habitats of 25 streams from three different catchments that also were sampled by Fisher. Updated and additional habitat evaluations were required because some habitat measures were not included in Fisher's study that are requisite in our analyses. Site locations were determined from his site descriptions (Table 11; Appendix C in Fisher 1989). Habitat evaluations were conducted as described above in early September 1993 and mid-July 1994, with macro-invertebrate metrics calculated from Fisher's data. For assurance, we also collected macroinvertebrates from four of the sites and compared biotic metrics for macroinvertebrates with respective data from Fisher (1989). In addition, five streams from the Big Creek catchment and five from Panther Creek drainage were included to increase the number of examined sites to 35.

Validation of derived metrics was based on five streams disturbed by mining in the Panther Creek drainage. Claims for mining entail about 65% of the Panther Creek catchment area, and mining is a major land use in the NRM. Reconnaissance and habitat assessments were completed on 15 streams of the Panther Creek drainage, with 10 selected streams sampled using the same methodology as above. Five streams acted as the reference condition and five streams were variously impacted by mining activities (Fig. 3, Table 12). Two of the five mining-impacted streams (Blackbird and SF Big Deer Creeks) were influenced chemically (mostly) and physically, while the other three (Upper and Lower Napias and Arnett Creeks) were influenced primarily physically (from dredging operations) and had experienced some degree of temporal recovery (e.g., no mining activity for 20-40 years or longer).

Table 11. Locations of the NRM Ecoregion streams; descriptions from Fisher (1989).

Stream	Drainage	Sampling Location
Wendover Creek	Lochsa River	50m upstream of bridge on St. Hwy. 12.
Papoose Creek		USFS Road 563 below West Fk. Papoose Creek.
Shoot Creek		Bridge on USFS Road 373.
Doe Creek		USFS Rd. 566 above unnamed trib. 3km from Squaw Creek.
Postoffice Creek		Bridge on USFS Road 564 at dead end.
Osier Creek	N. Fk. Clearwater River	USFS Road 737 at confl. w/ China Cr.
Goose Creek		USFS Trail 414, 200m above mouth.
Cayuse Creek		500m upstream of bridge on USFS Road 581.
Little Moose Creek		Bridge on USFS Road 255.
Flat Creek	Coeur D'Alene River	Bridge on USFS Rd. 400 at jct. w/ Svee Creek.
Falls Creek		Bridge on USFS Rd. 151 8km form mouth at Shoshone Creek.
Teepee Creek		Junction with Little Elk Creek.
Yellow Dog Creek		USFS Road 513 10km from mouth on Coeur D'Alene River.
Cinnamon Creek		Bridge on USFS Road 208 1km from mouth at Coeur D'Alene River.

Table 11. (cont.)

Eagle Creek	St. Joe River	5 km from mouth on USFS road 1214.
Quartz Creek		4 km from mouth on USFS road 339.
Gold Creek		USFS road 338 at Jct. with Berge Creek.
Red Ives Creek		3 km from mouth on USFS road 320.
Outlaw Creek		4 km from mouth at Fishhook Creek on USFS road 1928.
Prospector Creek		1 km from mouth on USFS road 752.
Powelson Creek	Payette River	Bridge on USFS road 401.
Rapid Creek		Deadend on USFS road 390.
Little Goose Creek	Salmon River	Bridge on USFS road 257.
MF Weiser River	Weiser River	First bridge from headwaters on USFS road 186.
Little Weiser River		Bridge on USFS road 206 upstream from junction with Anderson Creek.

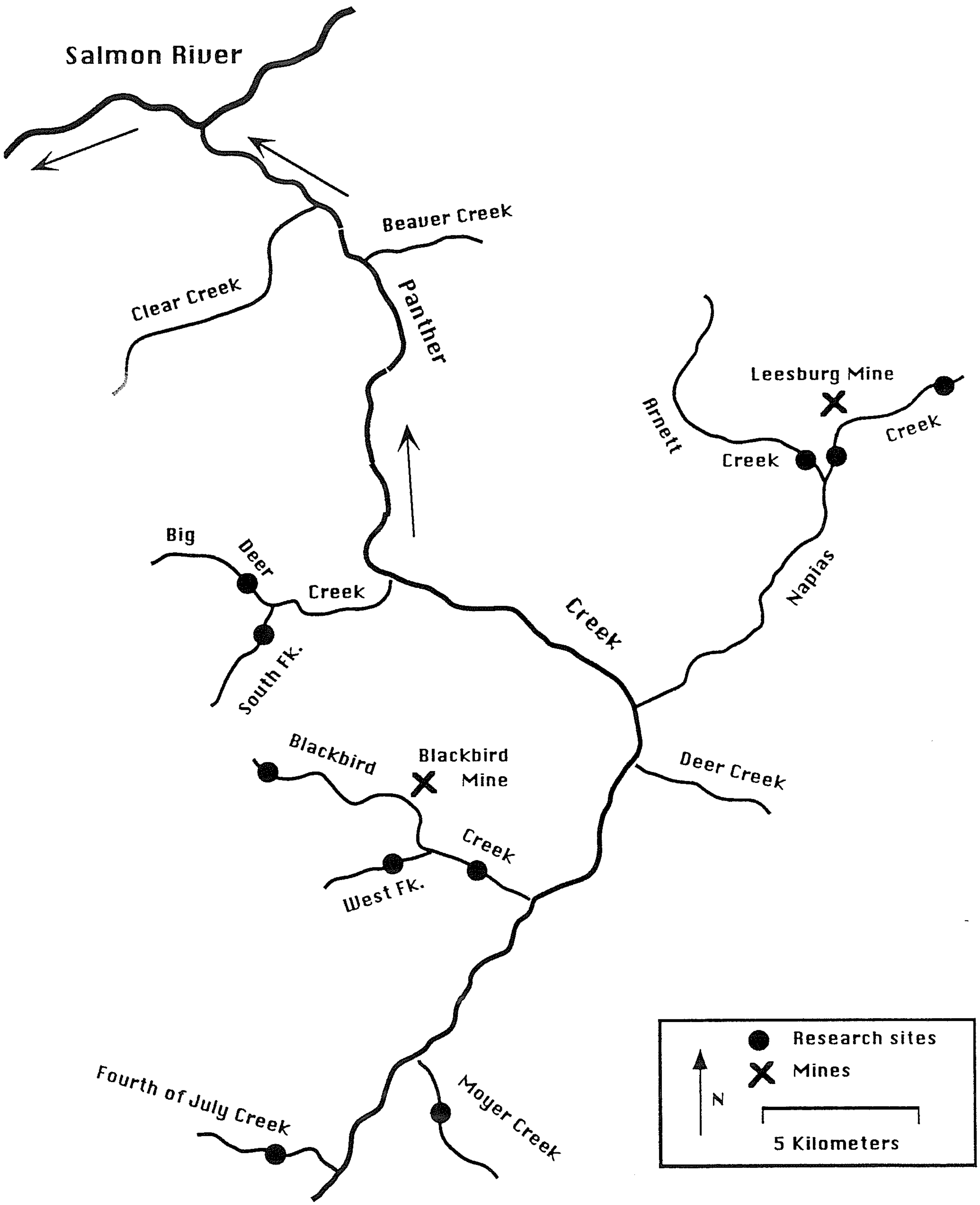


Figure 3. Map showing locations of sampling sites and mines in the Panther Creek drainage.

Table 12. Specific locations of Panther Creek study sites. MI and MC indicate Mining Impacted and Mining Control, respectively.

STATION	ECOREGION	TYPE	ELEVATION (m)	LONGITUDE	LATITUDE	TOWNSHIP	RANGE	SECTION
*Arnett	NCF	MI	1950	45 18'	114 07'	T22N	R20E	29
*Blackbird	NCF	MI	1750	45 05'	114 18'	T21N	R18E	35
*Lower Napias	NCF	MI	2000	45 17'	114 07'	T22N	R20E	20
*SF Big Deer	NCF	MI	1600	45 23'	114 22'	T21N	R18E	8
*Upper Napias	NCF	MI	2100	45 16'	114 06'	T22N	R20E	15
*Big Deer	NCF	MC	1550	45 23'	114 22'	T21N	R18E	8
*Fourth of July	NCF	MC	1950	45 00'	114 21'	T19N	R18E	9
*Moyer	NCF	MC	2000	45 01'	114 16'	T20N	R18E	35
*Upper Blackbird	NCF	MC	2300	45 06'	114 21'	T21N	R18E	28
*WF Blackbird	NCF	MC	2000	45 05'	114 18'	T20N	R18E	2
Little Deer	NCF	MC	1400	45 09'	114 17'	T21N	R18E	12
Woodtick	NCF	MC	1850	45 04'	114 16'	T20N	R19E	19
Musgrove	NCF	MC	1900	45 01'	114 19'	T20N	R18E	34
Deep	NCF	MC	1600	45 08'	114 14'	T21N	R19E	27
Beaver	NCF	MC	1400	45 17'	114 17'	T23N	R18E	36
Yellowjacket	NCF	MC	1700	45 01'	114 29'	T19N	R17E	4

* Indicates sites used for intensive survey.

Habitat Assessment and Biotic Measures for the NRM

The two-part habitat assessment data sheet (Table 2) was used during field reconnaissance. Periphyton chlorophyll a and ash-free-dry-mass (AFDM)(n=5), and amount of benthic organic matter (BOM) also were quantified at each sampled site as described above for the NBR and SRP ecoregions. Quantitative benthic samples were collected from four streams at five riffle/run habitats using a modified Hess net (250-μm mesh). Specimens of all macroinvertebrate taxa collected were retained for voucher collections and housed at the Stream Ecology Center of Idaho State University.

Because of the exploratory nature of this study, habitat variables and categories were compared among data sets using simple statistics. Habitat measures recorded by Fisher and also this study were evaluated using correlation analysis. Biotic metrics were calculated from the macroinvertebrate data from each site (after Fisher 1989) as described above for the NBR and SRP ecoregions. Respective scores for metrics were determined using recommendations in Plafkin et al. (1989) and based on the 90% confidence limits about the mean absolute value of Fisher's study sites. Scored metrics to distinguish among streams were determined using principal components analysis (PCA)(Statsoft 1991).

RESULTS

Habitat Assessment and Evaluation for NBR and SRP

Average habitat assessment scores were greater in upland sites than in lowland sites for both ecoregions (Fig. 4, Tables 5, 6). However, PCA revealed additional important measures for evaluating the integrity of aquatic habitats in the NBR and SRP ecoregions. This analysis indicated that inclusion of maximum water temperature and ionic concentrations (e.g. specific conductance, alkalinity, and total hardness) explained an

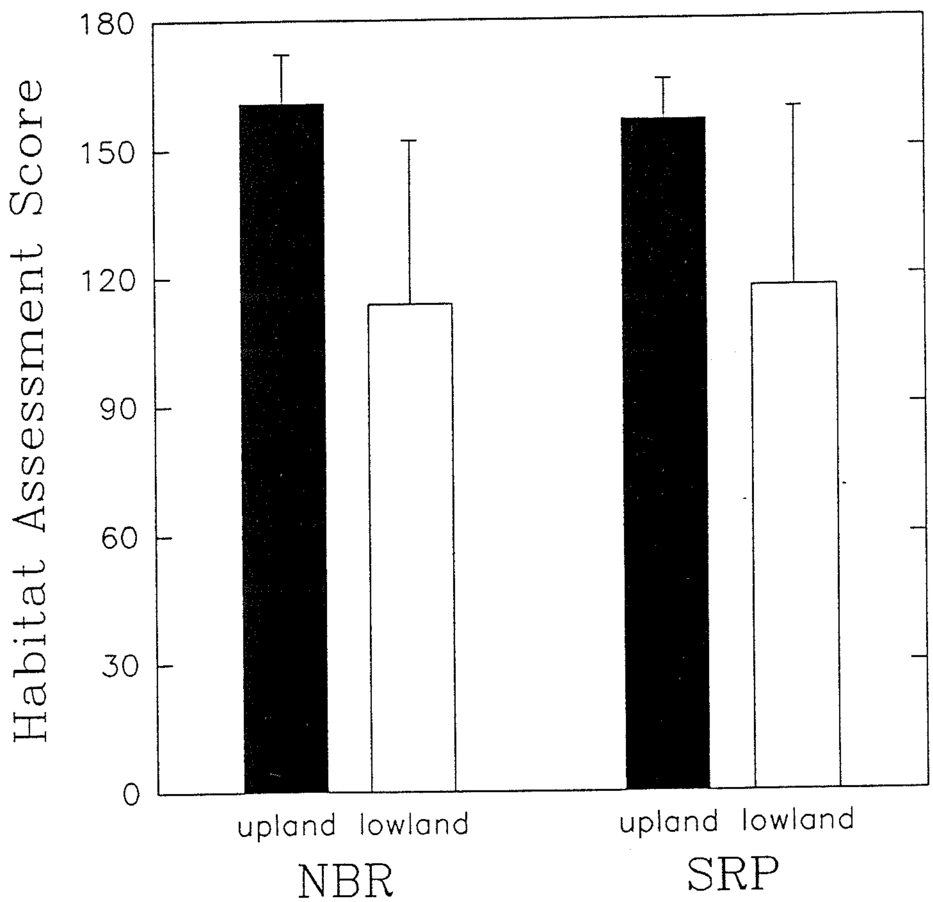


Fig. 4. Results for habitat assessment scores for upland and lowland streams within the NBR and SRP ecoregions in Idaho. Error bars equal +1 standard deviation from the mean; n=13, 19, 10, and 18, consecutively.

additional 10% of the variation among sites for both ecoregions (Fig. 5). For example, lowland sites displayed higher water temperatures and ionic concentrations than upland sites (Tables 7, 8). Further, PCA showed that eight of the 12 original habitat assessment categories were important for distinguishing between upland and lowland sites (Table 13). Upland sites from both ecoregions displayed dramatically similar mean habitat assessment scores (NBR=154.4, SRP=156.5), while lowland sites exhibited significantly lower mean scores than respective upland scores ($p>0.05$, NBR=109.6, SRP=121.7)(Fig. 6).

In 1991 and 1993, nutrient measures (nitrates and orthophosphorus) were incorporated into the study design and PCA was used to determine whether these measures also were important for distinguishing among upland and lowland sites. PCA revealed that these measures were relatively unimportant in distinguishing among reference and lowland sites for either ecoregion and only explained less than an additional 5% of the variation among sites. Concentrations of these measures displayed high variability among upland and lowland sites, although SRP lowland sites did have greater mean values of nitrates and phosphorus than upland sites (Tables 3, 4).

Other habitat measures also showed average, but nonsignificant, differences among upland and lowland sites because of high among-site variability. For example, mean chlorophyll a values were greater in lowland sites (NBR=2.74, SRP=2.13 $\mu g/cm^2$) relative to upland sites (NBR=0.50, SRP=0.84 $\mu g/cm^2$)($p=0.05$). In addition, average slopes (i.e. stream gradients) were greater in upland than lowland sites, and mean substrate size was lower and embeddedness values greater in lowland than in upland sites (Tables 3, 4). Further, the mean quantity of benthic organic matter (BOM) was greater in lowland streams than in upland streams ($p=0.05$).

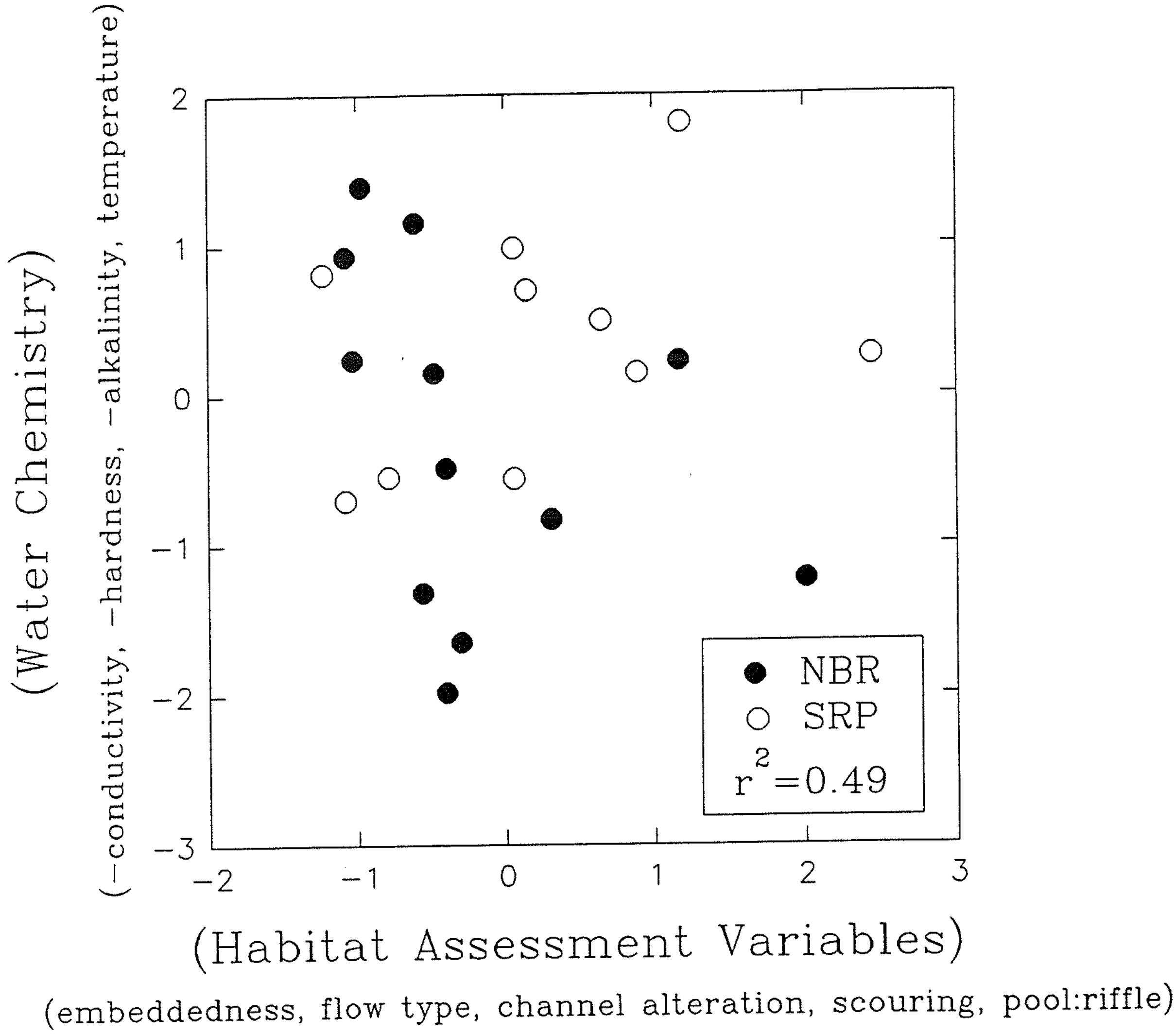


Figure 5. PCA scatterplot for upland reference sites based on habitat measures.

Table 13. Factor scores from principal components analysis for habitat measures recorded for streams in the Northern Basin and Range and Snake River Plain ecoregions of Idaho.

FACTOR	NBR-ecoregion FACTOR-1 SCORE	NBR-ecoregion FACTOR-2 SCORE	SRP-ecoregion FACTOR-1 SCORE	SRP-ecoregion FACTOR-2 SCORE
Elevation	-.196	-.147	-.068	-.107
Width:Depth Ratio	.106	-.142	-.118	.148
Stream Width	.359	.070	-.093	.014
Canopy Cover (%)	.019	-.855	.359	-.004
Periphyton-AFDM	.222	.215	-.178	.160
Chlorophyll a	.075	.385	.461	.428
Discharge	.297	.071	-.197	-.155
Temperature	-.126	.514	-.301	.424
Specific Conductance	-.457	.753	-.023	.883
Alkalinity	-.208	.867	-.102	.899
Total Hardness	-.294	.862	.033	.900
pH	-.403	.544	-.113	.082
Substrate Size	.248	-.566	.747	-.022
Embeddedness (%)	-.242	.542	-.493	.169
Slope	.217	-.603	.266	-.179
BOM	.238	.122	.002	.539
Substrate Cover	.739	-.331	.851	.043
Embeddedness	.691	-.160	.647	-.279
Flow Types	.813	-.293	.943	-.031
Canopy Cover	.055	-.725	.508	-.055
Channel Alteration	.898	-.156	.800	.025
Bottom Scouring	.838	-.272	.768	.052
Pool:Riffle Ratio	.915	-.089	.851	-.047
Width:Depth	.764	-.146	.531	.021
Bank Stability	.841	-.206	.364	-.031
Bank Vegetation	.820	-.022	.871	-.066
Stream Cover	.556	-.627	.645	-.151
Riparian Cover	.901	-.121	.297	-.313

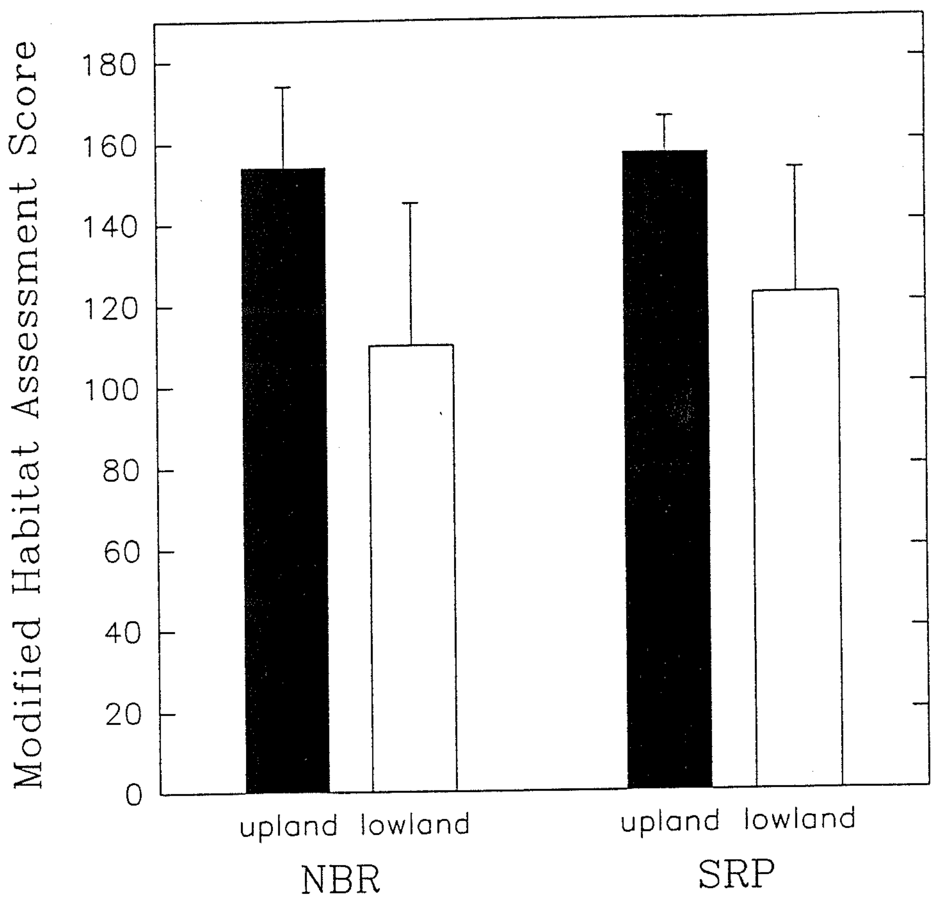


Fig. 6. Results using modified habitat assessment scores for upland and lowland streams within the NBR and SRP ecoregions in Idaho. Error bars equal +1 standard deviation from the mean; n=13, 19, 10, and 18, consecutively.

Macroinvertebrate Metric Development for NBR and SRP

Six of 18 community level metrics calculated were found important (based on PCA results) for discriminating among stream types for either ecoregion: species richness, EPT richness, Hilsenhoff Biotic Index (HBI), %Dominance, Shannon's (H') diversity, and Simpson's index (Fig. 7, Table 14). PCA results also revealed additional metrics useful for each ecoregion. For example, the metrics EPT/Chironomidae (CH), EPT/CH+Oligochaeta (O), %CH, and %CH+O were found important for distinguishing among streams in the NBR ecoregion, while %Scrapers and the ratio of Scrapers/Filterers were found important for the SRP ecoregion. The first two axes of the PCA explained 88% (NBR) and 78% (SRP) of the variation among sites within an ecoregion.

Multiple discriminant analysis (MDA) provided further insight into important metrics for distinguishing among upland and lowland sites within an ecoregion (Table 15, Fig. 8). For example, MDA suggested possible incorporation of the Hydropsychidae/Trichoptera ratio, although the p-level was only 0.14 for either ecoregion. MDA also indicated that the EPT index was highly important for distinguishing among NBR sites ($F=34.3$, $p<0.0001$), and the HBI was important for distinguishing among sites in the SRP ecoregion ($F=13.7$, $p=0.001$). Further, MDA revealed that upland sites were similar between NBR and SRP ecoregions, based on macroinvertebrate metrics, but that lowland sites were quite distinct between ecoregions ($F=3.53$, $p<0.001$)(Fig. 8). The difference between lowland streams was primarily attributed to differences in the EPT index and %CH+O; a finding also found by PCA.

In general, species richness, EPT richness, and H' diversity were greater, and %Dominance and Simpson's values lower in upland streams relative to lowland streams (Tables 16, 17). The HBI and BCI indices also reflected habitat conditions between stream types for each ecoregion. The metrics Hydropsychidae/Trichoptera ratio and %Shredders were found unimportant based on PCA results for either ecoregion, most likely because of high variation among sites. However, both of these metrics rely on collecting taxa

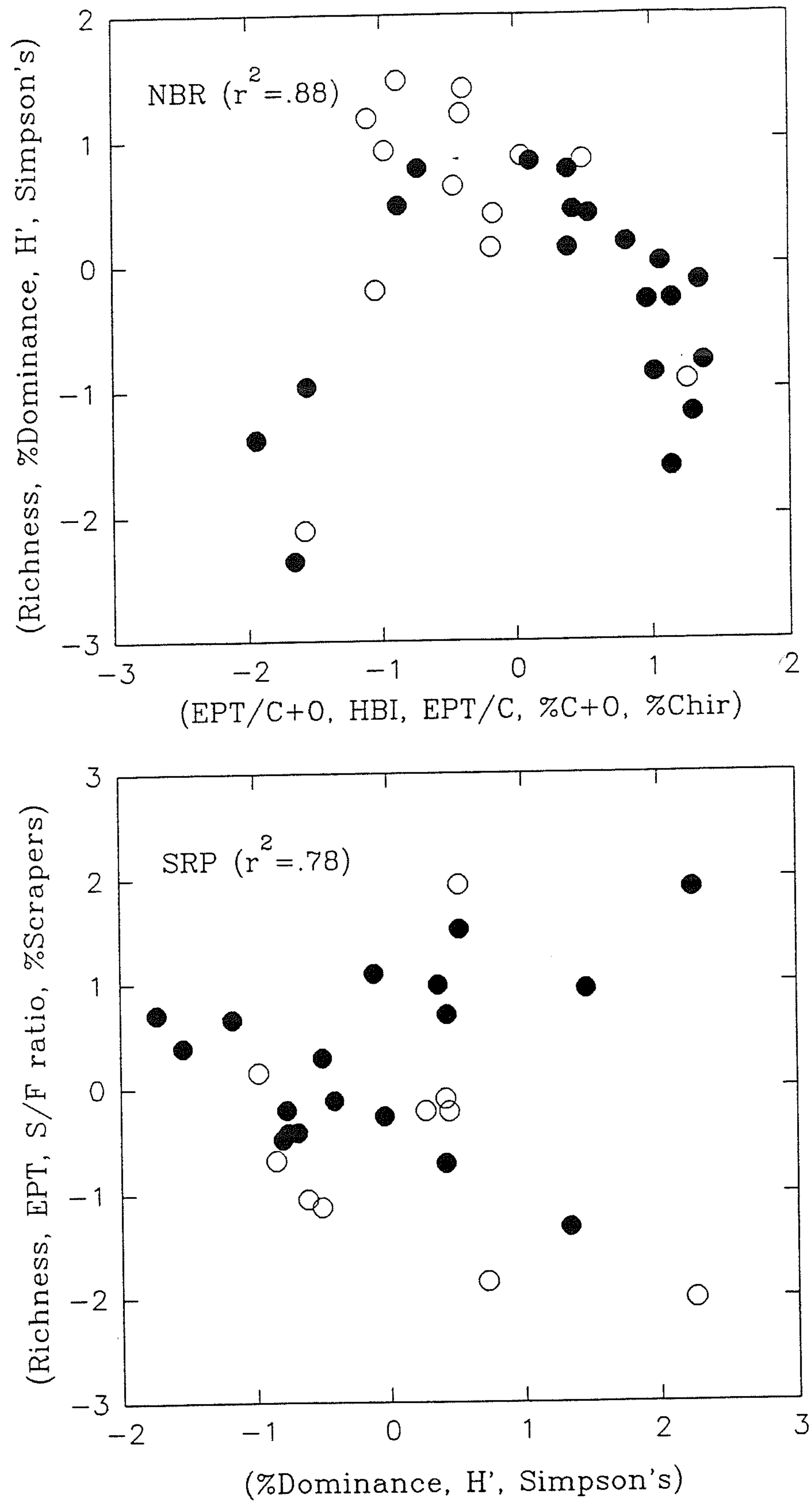


Fig. 7. PCA scatterplot based on macroinvertebrate metrics for streams in the NBR and SRP ecoregions.

Table 14. Factor scores from principal components analysis results based on macroinvertebrate metrics derived for the NBR and SRP ecoregions of Idaho.

BIOTIC METRIC	NBR FACTOR-1	NBR FACTOR-2	SRP FACTOR-1	SRP FACTOR2
EPT/Chir+Olig	.064	-.945	-.094	.058
Species Richness	.785	-.351	-.593	-.727
EPT Richness	.695	-.122	-.429	-.824
HBI Index	.659	-.445	.334	.162
BCI Index	.716	-.047	.010	-.579
EPT/Chironomidae	.058	-.891	-.141	-.258
%Dominance	.864	-.086	.888	-.127
Hydropsyche/Trichoptera	.197	.204	-.524	.131
H' Diversity	.917	-.142	-.938	-.276
Simpson's Index	.903	-.027	.941	.019
Scrapers/Filterers	.109	-.125	.257	-.864
%Scrapers	.261	-.535	-.031	-.579
%Filterers	-.150	.261	-.183	.309
%Shredders	.533	-.288	-.301	.312
% EPT	.483	-.625	-.324	-.189
%Chir+Olig	.209	-.922	.363	-.093
%Chironomidae	.115	-.852	-.100	.359

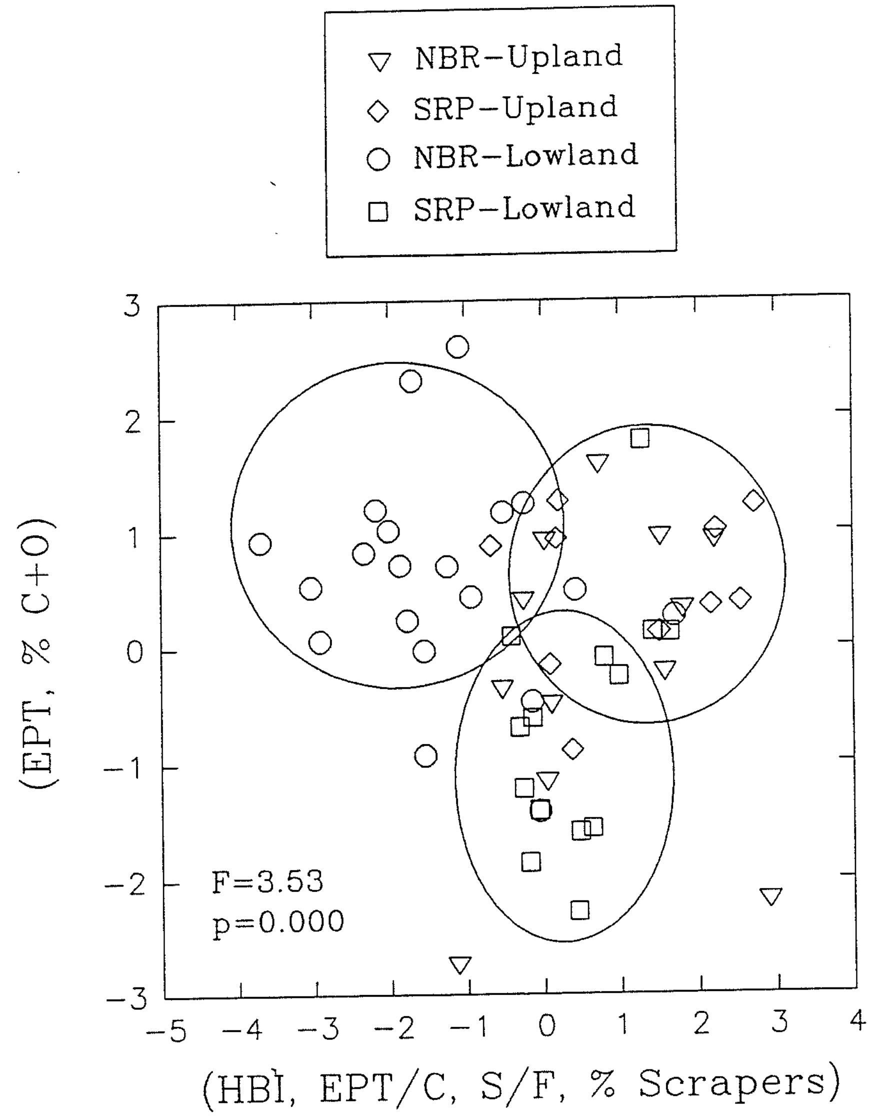


Fig. 8. Scattergram from MDA results based on the macroinvertebrate metrics. See text for further explanation. Circles fitted by eye to denote major groupings.

Table 15. F-values, p-levels, and standardized coefficients for variables (macroinvertebrate metrics) entered into the forward stepwise MDA and as illustrated in Figure.

Variable	F-value	p-level	Coefficients	
			Root-1	Root-2
EPT index	10.69	<.0001	.417	.762
HBI index	4.23	.0092	.963	-.202
%C+O	5.65	.0019	-.526	1.031
EPT/C	4.37	.008	.609	-.695
%Dominance	2.75	.052	-.189	.544
S/F ratio	1.33	.274	.754	.286
%Scrapers	2.24	.095	-.663	-.120
Hydro/Trich	1.63	.194	.294	.031
%EPT taxa	1.39	.257	.009	-.108
Species Richness	1.16	.334	-.419	-.126
BCI index	1.06	.376	.193	-.335

Table 16 (cont.).

STRM	SCRAPERS/ FILTERERS	SC	DENSITY (No./m2)	SC	% SCRAPER	SC	% FILTERERS	SC	% SHREDDER	SC	% EPT	SC	% CHIR+OLIG	SC	% CHIRONOMI	SC	PCA SCORE (F1+F2)	TOTAI SCOR
Lowland Sites																		
19	1.47	1			0.37	5	0.25	1	0.09	3	0.49	3	0.12	3	0.02	5	30	53
31	1.16	1			0.29	3	0.25	1	0.06	5	0.60	5	0.06	5	0.05	5	32	51
50	5.09	3	1502	5	0.69	5	0.13	3	0.01	1	0.86	5	0.03	5	0.02	5	28	49
73	18.00	5	6568	1	0.90	5	0.05	5	0.00	1	0.96	5	0.02	5	0.02	5	26	49
68	23.93	5	2010	3	0.31	3	0.01	5	0.00	1	0.35	1	0.43	1	0.41	1	16	41
18	0.67	1			0.16	1	0.24	1	0.00	1	0.33	1	0.18	3	0.16	3	26	39
64	0.12	1	8393	1	0.09	1	0.75	1	0.01	1	0.18	1	0.00	5	0.00	5	30	37
94	0.76	1	2517	3	0.06	1	0.08	3	0.02	3	0.12	1	0.27	1	0.19	1	18	35
49	25.75	5	8178	1	0.24	3	0.01	5	0.00	1	0.24	1	0.69	1	0.29	1	12	33
62	1.52	1	773	5	0.17	1	0.20	1	0.00	1	0.17	1	0.32	1	0.02	5	22	33
69	0.36	1	2654	3	0.05	1	0.13	3	0.03	3	0.07	1	0.57	1	0.57	1	10	29
86	9.67	5	9082	1	0.24	3	0.02	5	0.01	1	0.27	1	0.65	1	0.65	1	10	29
71	0.00	1	3358	1	0.00	1	0.03	5	0.00	1	0.00	1	0.85	1	0.06	3	12	27
28	1.17	1			0.13	1	0.12	3	0.00	1	0.31	1	0.37	1	0.32	1	18	27
85	15.01	5	3643	1	0.21	3	0.01	5	0.00	1	0.21	1	0.62	1	0.48	1	10	27
65	1.61	3	6895	1	0.02	1	0.01	5	0.00	1	0.04	1	0.88	1	0.75	1	10	27
61	1.40	1	547	5	0.10	1	0.07	3	0.00	1	0.12	1	0.59	1	0.34	1	12	25
67	0.81	1	3635	1	0.06	1	0.07	3	0.03	3	0.09	1	0.75	1	0.55	1	10	25
66	0.47	1	5612	1	0.01	1	0.03	5	0.00	1	0.02	1	0.94	1	0.26	1	10	25
60	0.32	1	29137	1	0.07	1	0.21	1	0.00	1	0.12	1	0.65	1	0.53	1	10	21
Upland Sites																		
36	13.53	5	4129	1	0.62	5	0.05	5	0.02	3	0.75	5	0.07	5	0.03	5	50	81
1	3.15	3			0.51	5	0.16	3	0.03	3	0.65	5	0.09	3	0.08	3	42	71
37	6.67	5	4512	1	0.25	3	0.04	5	0.08	5	0.41	3	0.12	3	0.09	3	38	69
35	87.00	5	1199	5	0.55	5	0.01	5	0.02	3	0.59	5	0.06	5	0.05	5	36	67
92	1.03	1	2751	3	0.18	1	0.17	1	0.14	5	0.57	5	0.04	5	0.02	5	46	67
90	3.67	3	969	5	0.19	3	0.05	5	0.05	3	0.48	3	0.21	1	0.03	5	36	57
3	3.80	3			0.26	3	0.07	3	0.03	3	0.33	1	0.01	5	0.01	5	30	49
5	2.69	3			0.30	3	0.11	3	0.06	5	0.48	3	0.36	1	0.36	1	22	43
93	3.07	3	2536	3	0.26	3	0.08	3	0.00	1	0.36	3	0.40	1	0.28	1	20	39
2	0.04	1			0.04	1	0.92	1	0.00	1	0.05	1	0.01	5	0.01	5	24	37
79	0.41	1	858	5	0.18	1	0.43	1	0.02	3	0.34	1	0.17	3	0.16	3	22	35
8	0.44	1			0.08	1	0.18	1	0.05	3	0.28	1	0.18	3	0.17	1	18	27
Lowland mean	5.46		5907		0.21		0.13		0.01		0.28		0.45		0.29		17.60	34.1
stderr	1.86		1507		0.05		0.04		0.01		0.06		0.07		0.05		1.81	2.1
stddev	8.13		6572		0.22		0.16		0.02		0.26		0.30		0.24		8.01	9.6
Upland mean	3.50		2422		0.28		0.12		0.04		0.44		0.14		0.11		32.00	53.5
stderr	1.06		401		0.05		0.03		0.01		0.05		0.04		0.03		3.25	5.2
stddev	23.35		1386		0.18		0.24		0.04		0.18		0.12		0.11		10.39	16.6
mean-cl90%	1.59		1701		0.19		0.06		0.02		0.35		0.08		0.05			
mean+cl90%	5.41		3143		0.37		0.17		0.06		0.53		0.21		0.17			
SCORE																		
5	>5.4		<1700		>.37		<.06		>.06		>.53		<.08		<.05			
3	1.6-5.4		1700-3150		.19-.37		.06-.17		.02-.06		.35-.53		.08-.21		.05-.17			
1	<1.6		>3150		<.19		>.17		<.02		<.35		>.21		>.17			

Table 16. Absolute and respective scores for macroinvertebrate metrics for streams in the NBR ecoregion. Scores based on PCA results and for all metrics combined. Note: SC equals SCORE.

STRM	EPT/ (CHIR+OLIG)	SC	SPECIES RICHNESS	SC	EPT RICHNESS	SC	HBI INDEX	SC	BCI INDEX	SC	EPT/ CHIRONOMID	SC	% DOMINANC	SC	HYDROPSYCHE/ TRICHOPTERA	SC	H' DIVERSITY	SC	SIMPSON' INDEX
Lowland Sites																			
19	4.3	3	18	1	7	1	4.93	1	90	5	25.5	5	0.29	3	0.00	5	2.35	3	0.13
31	9.8	3	18	1	8	1	3.26	5	62	1	11.9	3	0.28	3	0.03	3	2.09	3	0.17
50	34.4	5	19	3	9	1	4.43	1	78	3	39.3	5	0.69	1	0.60	1	1.36	1	0.48
73	42.4	5	13	1	6	1	4.77	1	69	1	42.9	5	0.86	1	1.00	1	0.64	1	0.75
68	0.8	1	22	3	14	3	5.04	1	86	5	0.8	1	0.41	3	0.12	5	1.63	1	0.28
18	1.8	1	19	3	7	1	4.49	1	80	3	2.0	1	0.18	5	0.00	5	2.37	3	0.12
64	65.4	5	22	3	11	3	5.25	1	72	1	84.3	5	0.74	1	0.50	1	1.13	1	0.56
94	0.5	1	21	3	9	1	4.47	1	79	3	0.6	1	0.37	3	0.00	5	2.10	3	0.20
49	0.3	1	11	1	3	1	5.20	1	62	1	0.8	1	0.40	3	0.00	5	1.48	1	0.28
62	0.5	1	17	1	4	1	5.20	1	54	1	6.8	3	0.29	3	0.00	5	2.22	3	0.16
69	0.1	1	17	1	5	1	5.66	1	94	5	0.1	1	0.57	1	0.00	5	1.60	1	0.36
86	0.4	1	9	1	4	1	5.47	1	67	1	0.4	1	0.65	1	0.13	3	1.05	1	0.48
71	0.0	1	10	1	0	1	5.48	1	61	1	0.0	1	0.80	1	0.00	5	0.89	1	0.64
28	0.8	1	18	1	9	1	4.29	3	68	1	1.0	1	0.32	3	0.35	1	2.11	3	0.18
85	0.3	1	11	1	2	1	5.92	1	51	1	0.4	1	0.48	1	1.00	1	1.45	1	0.31
65	0.0	1	16	1	7	1	5.68	1	59	1	0.0	1	0.75	1	0.00	5	0.94	1	0.59
61	0.2	1	11	1	3	1	6.49	1	56	1	0.3	1	0.34	3	0.00	5	1.79	1	0.21
67	0.1	1	16	1	7	1	5.35	1	60	1	0.2	1	0.55	1	0.00	5	1.48	1	0.35
66	0.0	1	7	1	2	1	5.32	1	60	1	0.1	1	0.68	1	0.00	5	0.86	1	0.53
60	0.2	1	16	1	5	1	5.57	1	59	1	0.2	1	0.53	1	0.00	5	1.39	1	0.35
Upland Sites																			
36	10.8	5	25	5	15	5	3.36	5	86	5	22.5	5	0.26	5	0.14	3	2.50	5	0.13
1	7.3	3	31	5	21	5	3.28	5	92	5	7.6	3	0.20	5	0.00	5	2.71	5	0.10
37	3.5	3	28	5	17	5	3.74	5	87	5	4.5	1	0.28	3	0.00	5	2.57	5	0.13
35	10.4	5	19	3	9	1	4.14	3	81	3	12.5	3	0.26	5	0.00	5	2.08	3	0.17
92	15.0	5	21	3	12	3	3.72	5	80	3	37.5	5	0.16	5	0.00	5	2.44	5	0.11
90	2.3	1	22	3	12	3	3.55	5	81	3	14.9	3	0.18	5	0.33	1	2.75	5	0.09
3	24.3	5	21	3	10	1	4.18	3	65	1	32.3	5	0.56	1	0.00	5	1.67	1	0.36
5	1.3	1	22	3	16	5	4.41	1	83	3	1.3	1	0.36	3	0.45	1	2.21	3	0.18
93	0.9	1	23	3	12	3	4.72	1	74	1	1.3	1	0.28	3	0.00	5	2.35	3	0.14
2	3.5	3	11	1	7	1	3.04	5	81	3	3.5	1	0.92	1	0.00	5	0.45	1	0.85
79	2.0	1	22	3	11	3	5.42	1	73	1	2.1	1	0.41	3	0.00	5	2.04	3	0.22
8	1.6	1	17	1	10	1	4.24	3	72	1	1.6	1	0.45	3	0.83	1	1.85	3	0.25
Lowland mean	8.1		15.6		6.1		5.11		68.4		10.9		0.51		0.19		1.55		0.36
stderr	4.0		1.0		0.8		0.16		2.7		4.9		0.04		0.07		0.12		0.04
stddev	17.4		4.3		3.3		0.68		12.0		21.2		0.20		0.32		0.52		0.18
Upland mean	6.9		21.8		12.7		3.98		79.5		11.8		0.36		0.15		2.13		0.17
stderr	2.0		1.4		1.1		0.19		2.1		3.5		0.06		0.07		0.17		0.02
stddev	6.8		4.9		3.7		0.65		7.3		12.1		0.20		0.25		0.60		0.20
mean-cl90%	3.4		19.3		10.7		3.65		75.7		5.5		0.26		0.01		1.82		0.13
mean+cl90%	10.5		24.4		14.6		4.32		83.3		18.1		0.47		0.28		2.45		0.21
SCORE																			
5	>10.5		>24.4		>14.6		<3.7		>83.3		>18.1		<.26		<.01		>2.45		<.13
3	3.4-10.5		19-24.4		10.7-14.6		3.7-4.3		75.7-83.3		5.5-18.1		.26-.47		.01-.28		1.82-2.45		.13-.21
1	<3.4		<19		<10.7		>4.3		<75.7		<5.5		>.47		>.28		<1.82		>.21

Table 17. Absolute and respective scores for macroinvertebrate metrics for streams in the SRP ecoregion. Scores summed based on PCA results and for all metrics combined. Note: SC equals SCORE.

STRM	EPT/ CHIR+OLIG	SC	SPECIES RICHNESS	SC	EPT RICHNESS	SC	HBI INDEX	SC	BCI INDEX	SC	EPT/ CHIRONOMI	SC	% DOMINANCE	SC	HYDROPSYCHE/ TRICHOPTERA	SC	H' DIVERSITY	SC	SIMPSON'S INDEX	S
Lowland Sites																				
46	1.5	3	23	5	12	3	3.95	3	82	3	1.5	1	0.22	5	0.04	3	2.33	5	0.13	
45	1.0	3	22	3	12	3	3.79	3	94	3	1.6	1	0.21	5	0.00	5	2.48	5	0.12	
17	1.6	3	24	5	12	3	4.14	1	69	1	1.7	3	0.29	5	0.29	1	2.23	3	0.16	
32	3.0	3	23	5	8	1	4.61	1	57	1	4.0	3	0.12	5	0.63	1	2.73	5	0.08	
15	1.5	3	20	3	10	3	4.13	1	68	1	1.8	3	0.22	5	0.24	1	2.45	5	0.11	
52	2.7	3	19	3	10	3	4.77	1	78	1	3.0	3	0.52	1	0.00	5	1.66	1	0.32	
27	2.4	3	21	3	9	1	3.81	3	70	1	2.6	3	0.21	5	1.00	1	2.44	5	0.12	
63	1.2	3	20	3	6	1	5.71	1	60	1	1.3	1	0.35	3	0.00	5	2.02	3	0.23	
53	14.1	5	14	1	5	1	4.87	1	78	1	0.0	1	0.45	1	0.00	5	1.52	1	0.30	
44	1.4	3	21	3	9	1	4.17	1	93	3	1.7	3	0.43	3	0.46	1	1.99	3	0.23	
72	0.8	3	12	1	6	1	5.09	1	95	3	1.3	1	0.34	3	0.00	5	1.78	1	0.21	
70	0.8	3	15	1	4	1	4.49	1	74	1	1.1	1	0.31	3	0.00	5	2.10	3	0.17	
29	0.7	3	24	5	9	1	5.19	1	69	1	0.8	1	0.38	3	0.00	5	2.22	3	0.19	
16	0.4	1	30	5	10	3	4.68	1	66	1	0.4	1	0.39	3	0.22	1	2.24	3	0.21	
51	1.1	3	10	1	4	1	4.27	1	67	1	3.1	3	0.30	3	0.00	5	1.68	1	0.22	
48	0.6	3	19	3	9	1	4.66	1	72	1	0.8	1	0.40	3	0.32	1	2.18	3	0.19	
47	0.0	1	8	1	2	1	5.45	1	60	1	0.0	1	0.69	1	0.00	5	1.05	1	0.51	
26	0.5	3	16	1	6	1	5.49	1	57	1	0.5	1	0.48	1	0.14	1	1.62	1	0.31	
Upland Sites																				
38	2.7	3	22	3	12	3	3.57	3	86	3	8.4	5	0.14	5	0.00	5	2.56	5	0.10	
40	1.2	3	24	5	16	5	3.94	3	97	5	1.8	3	0.27	5	0.00	5	2.36	5	0.14	
41	1.1	3	24	5	17	5	3.19	5	106	5	2.8	3	0.25	5	0.00	5	2.52	5	0.12	
42	0.8	3	24	5	18	5	3.60	3	123	5	0.0	1	0.49	1	0.00	5	2.06	3	0.27	
43	1.2	3	27	5	16	5	4.07	3	86	3	1.6	1	0.32	3	0.00	5	2.43	5	0.15	
4	8.3	5	17	1	10	3	3.16	5	77	1	8.3	5	0.33	3	0.29	1	1.91	3	0.21	
80	1.3	3	12	1	5	1	3.08	5	69	1	1.4	1	0.36	3	0.00	5	1.54	1	0.28	
39	0.3	1	21	3	13	3	4.46	1	86	3	12.0	5	0.71	1	0.00	5	1.34	1	0.51	
89	0.5	3	17	1	9	1	4.37	1	78	1	0.5	1	0.42	3	0.00	5	1.78	1	0.26	
88	0.4	1	18	3	7	1	4.45	1	67	1	1.4	1	0.38	3	0.00	5	1.81	3	0.23	
Lowland mean	1.96		18.94		7.94		4.63		72.80		1.52		0.35		0.19		2.04		0.21	
stderr	0.70		1.24		0.67		0.13		2.69		0.24		0.03		0.06		0.09		0.02	
stddev	3.04		5.39		2.91		0.57		11.72		1.06		0.13		0.27		0.41		0.10	
Upland mean	1.79		20.60		12.30		3.79		87.53		3.83		0.37		0.03		2.03		0.23	
stderr	0.72		1.36		1.34		0.16		5.20		1.25		0.05		0.03		0.13		0.04	
stddev	2.26		4.29		4.24		0.52		16.43		3.93		0.15		0.09		0.40		0.11	
mean-cl90%	0.47		18.11		9.84		3.49		78.00		1.55		0.28		-0.02		1.80		0.16	
mean+cl90%	3.10		23.09		14.76		4.09		97.07		6.11		0.45		0.08		2.26		0.29	
SCORE																				
5	>3.1		>23		>14.8		<3.49		>97.1		>6.1		<.28		<.01		>2.26		<.16	
3	.47-3.1		18-23		9.8-14.8		3.49-4.09		78-97.1		1.6-6.1		.28-.45		.01-.08		1.8-2.26		.16-.29	
1	<.48		<18		<9.8		>4.09		<78		<1.6		>.45		>.08		<1.8		>.29	

Table 17 (cont.).

STRM	SCRAPERS/ FILTERERS	SC	DENSITY (No./m2)	SC	% SCRAPERS	SC	% FILTERERS	SC	% SHREDDERS	SC	% EPT	SC	% CHIR+OLIG	SC	% CHIRONOMID	SC	PCA SCORE (F1+F2)	TOTA SCOR
Lowland Sites																		
46	4.00	3	892	5	0.21	3	0.05	1	0.01	3	0.33	3	0.22	5	0.22	3	29	57
45	3.29	1	1072	5	0.18	3	0.05	1	0.02	3	0.34	3	0.34	3	0.21	3	25	53
17	11.88	3			0.30	5	0.02	3	0.13	3	0.50	5	0.32	3	0.29	1	29	53
32	0.90	1			0.20	3	0.22	1	0.06	3	0.45	3	0.15	5	0.11	3	25	49
15	1.53	1			0.10	1	0.06	1	0.19	5	0.38	3	0.25	5	0.22	3	23	49
52	34.00	5	1356	5	0.59	5	0.02	3	0.00	1	0.64	5	0.23	5	0.21	3	19	49
27	0.75	1			0.15	3	0.21	1	0.00	1	0.53	5	0.23	5	0.20	1	23	47
63	33.00	5	760	5	0.36	5	0.01	5	0.00	1	0.41	3	0.33	3	0.31	1	23	47
53	1.48	1	13595	1	0.45	5	0.31	1	0.08	3	0.55	5	0.04	5	0.00	5	11	43
44	3.08	1	6937	1	0.11	1	0.04	3	0.01	1	0.25	1	0.18	5	0.15	3	15	39
72	0.55	1	1923	5	0.19	3	0.34	1	0.01	3	0.28	1	0.35	3	0.22	3	13	37
70	1.79	1	4265	1	0.10	1	0.05	1	0.18	5	0.34	3	0.44	3	0.31	1	13	37
29	1.19	1			0.15	3	0.13	1	0.00	1	0.32	1	0.48	3	0.38	1	19	37
16	2.00	1			0.06	1	0.03	3	0.02	3	0.16	1	0.42	3	0.39	1	19	35
51	0.05	1	4505	1	0.01	1	0.11	1	0.00	1	0.46	3	0.43	3	0.15	3	11	35
48	1.80	1	1278	5	0.05	1	0.03	3	0.05	3	0.33	1	0.51	1	0.40	1	15	31
47	0.00	1	2412	3	0.00	1	0.00	5	0.01	1	0.03	1	0.78	1	0.69	1	7	25
26	0.18	1			0.09	1	0.48	1	0.00	1	0.15	1	0.29	5	0.28	1	7	23
Upland Sites																		
38	0.00	1	6260	1	0.24	3	0.00	5	0.15	5	0.53	5	0.20	5	0.06	5	25	69
40	13.50	3	1697	5	0.26	3	0.02	3	0.05	3	0.50	5	0.43	3	0.27	1	31	65
41	2.21	1	2251	3	0.21	3	0.09	1	0.07	3	0.49	5	0.43	3	0.17	3	29	65
42	21.33	5	2400	3	0.25	3	0.01	5	0.04	3	0.40	3	0.49	3	0.00	5	25	61
43	8.88	3	1394	5	0.24	3	0.03	3	0.03	3	0.49	5	0.40	3	0.32	1	29	59
4	6.40	3			0.46	5	0.07	1	0.01	3	0.54	5	0.06	5	0.06	5	21	57
80	0.00	1	2243	3	0.02	1	0.00	5	0.35	5	0.53	5	0.40	3	0.36	1	11	45
39	44.00	5	3464	3	0.16	3	0.00	5	0.00	1	0.22	1	0.73	1	0.02	5	17	45
89	7.14	3	3291	3	0.14	1	0.02	3	0.01	3	0.23	1	0.44	3	0.42	1	13	35
88	4.29	3	2125	3	0.07	1	0.02	3	0.00	1	0.19	1	0.52	1	0.13	3	17	35
Lowland mean	5.64		3545.1		0.18		0.12		0.04		0.36		0.33		0.26		18.11	41.
stderr	2.34		843.3		0.03		0.03		0.01		0.03		0.04		0.03		1.60	2.2
stddev	10.19		3676.8		0.15		0.13		0.06		0.15		0.16		0.14		6.77	9.4
Upland mean	10.78		2791.7		0.20		0.03		0.07		0.41		0.41		0.18		21.80	53.
stderr	4.01		435.9		0.04		0.01		0.03		0.04		0.05		0.05		2.12	3.7
stddev	12.67		1377.4		0.11		0.03		0.10		0.14		0.17		0.14		6.71	11.
mean-cl90%	3.42		1992.7		0.14		0.01		0.01		0.33		0.31		0.10			
mean+cl90%	18.13		3590.7		0.27		0.04		0.13		0.49		0.51		0.27			
SCORE																		
5	>18.1		<2000		>.27		<.01		>.13		>.49		<.31		<.10			
3	3.4-18.1		2000-3590		.14-.27		.01-.04		.01-.13		.33-.49		.31-.51		.10-.27			
1	<3.4		>3590		<.14		>.04		<.01		<.33		>.51		>.27			

that primarily have life histories that are univoltine and/or cued by a seasonal resource (such as leaf fall for many shredder taxa), thus stressing the influence of sampling time (e.g., seasonal) on the response by various metrics.

A score of 5 indicated optimal values for each metric based on 90% confidence limits around the average reference value (Tables 16, 17) and resulted in a maximum summed score of 50 for NBR ecoregion (10 metrics) and 40 for SRP ecoregion (8 metrics). Scores ranged from 10 to 50 for NBR streams, and from 7 to 31 for SRP sites. The average metric score was 32 for NBR upland streams and 18 for lowland streams, while SRP upland streams averaged 22 and lowland streams 18 (Figs. 9, 10). The macroinvertebrate metric score displayed a positive but weak regression against the habitat assessment score (r^2=0.10, NBR; r^2=0.25 ,SRP) (Figs. 9, 10).

Macroinvertebrate Taxa Analysis for NBR and SRP

Multivariate statistics also were performed using the relative abundances of the 15-20 most abundant taxa collected among all sites (Table 18a,b). These taxa generally comprised over 80% of the macroinvertebrate assemblage at any one site. The initial PCA results revealed that taxa of the Heptageniidae (e.g. the genera *Heptagenia, Epeorus, Cinygmula,* and *Rhithrogena*), Elmidae (e.g. the genera *Heterlimnius, Optioservus,* and *Cleptelmis*), and predaceous Rhyacophilidae (all collected species except *Rhyacophila acropedes*) were predominant in upland sites; thus abundances of these taxa were combined at the family level for future analyses. In addition, densities of *Drunella* and *Ephemerella* species were combined at the generic level because of low abundances. All combined taxa had identical tolerance (HBI and BCI) values.

PCA results, based on macroinvertebrate taxa, indicated that the first two axes explained 61% (NBR) and 54% (SRP) of the variation among sites within ecoregions. Axis-1 for each ecoregion was described by Heptageniidae, Rhyacophilidae, *Capnia,*

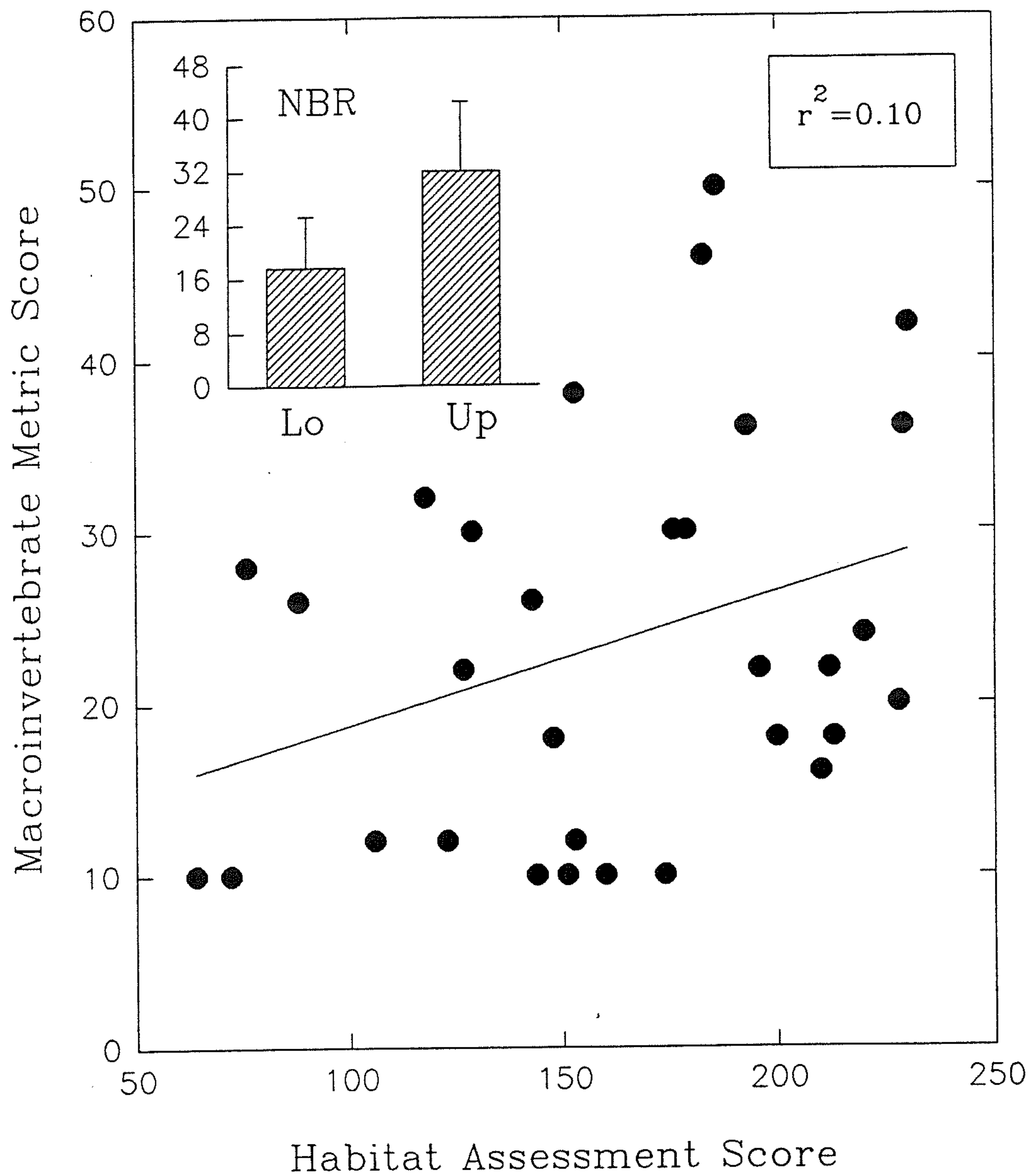


Fig. 9. Regression of the habitat assessment score against the macroinvertebrate metric score in the NBR ecoregion. Inset reflects average metric score for lowland and upland streams; error bars equal +1 standard deviation from the mean; n=19 and 13 for lowland and upland sites, respectively.

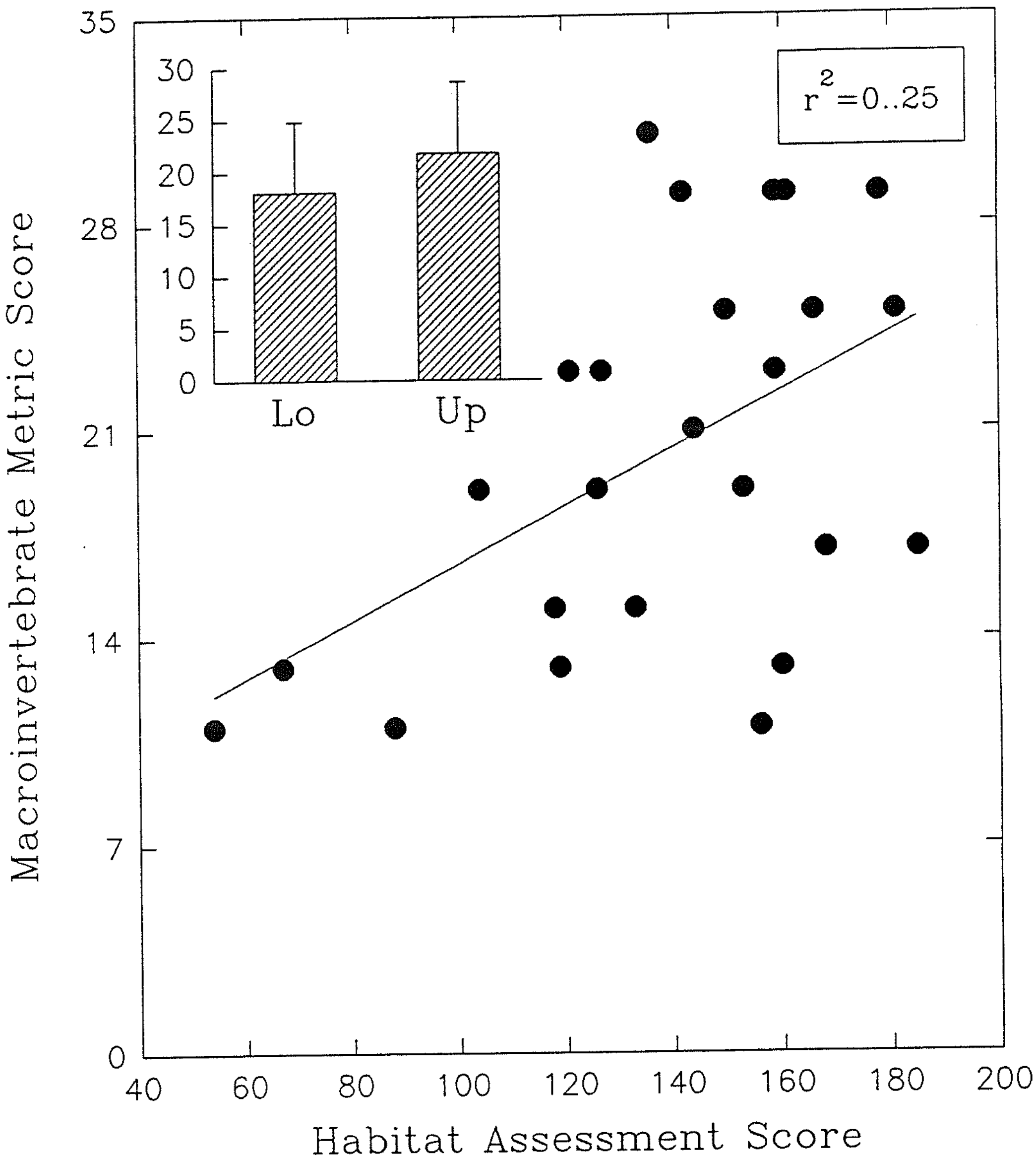


Fig. 10. Regression of the habitat assessment score against the macroinvertebrate metric score in the SRP ecoregion. Inset reflects average metric score for lowland and upland streams; error bars equal +1 standard deviation from the mean; n=18 and 10 for lowland and upland sites, respectively.

Table 18a. Relative abundances of most common taxa, except Chironomidae and Oligochaeta, collected from the NBR sites.

Stream	Baetis	Elmidae	Heptageniidae	Zapada	Rhyacophilidae	Brachycentrus	Ephemerella	Hexatoma	Hyallela	Capnia	Drunella	Turbellaria	Sialis
Northern Basin and Range - Lowland Sites													
18	0.035	0.090	0.003	0.000	0.000	0.147	0.118	0.058	0.185	0.000	0.000	0.006	0.000
19	0.285	0.016	0.000	0.000	0.000	0.016	0.087	0.003	0.058	0.000	0.000	0.000	0.000
28	0.062	0.231	0.004	0.000	0.069	0.038	0.062	0.000	0.000	0.000	0.000	0.000	0.000
31	0.282	0.159	0.004	0.000	0.000	0.217	0.025	0.000	0.000	0.000	0.000	0.000	0.000
49	0.189	0.051	0.048	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50	0.687	0.003	0.000	0.000	0.009	0.041	0.000	0.028	0.000	0.000	0.000	0.000	0.000
60	0.069	0.004	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000
61	0.096	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.000	0.000	0.000	0.000
62	0.020	0.219	0.098	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
64	0.037	0.020	0.043	0.009	0.000	0.003	0.015	0.000	0.000	0.000	0.000	0.000	0.000
65	0.020	0.062	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000
66	0.013	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
67	0.031	0.073	0.024	0.000	0.000	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000
68	0.281	0.180	0.011	0.002	0.004	0.000	0.000	0.005	0.000	0.000	0.004	0.000	0.000
69	0.024	0.123	0.000	0.009	0.000	0.000	0.000	0.000	0.049	0.000	0.000	0.000	0.000
71	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.000
73	0.860	0.011	0.000	0.000	0.000	0.000	0.038	0.001	0.000	0.000	0.000	0.000	0.000
85	0.241	0.050	0.000	0.000	0.000	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000
86	0.204	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.131	0.000	0.000	0.000	0.000
94	0.000	0.394	0.045	0.010	0.000	0.000	0.000	0.010	0.000	0.000	0.015	0.000	0.000
Northern Basin and Range - Upland Sites													
1	0.075	0.047	0.329	0.003	0.027	0.010	0.000	0.000	0.000	0.010	0.088	0.047	0.000
2	0.010	0.019	0.016	0.003	0.000	0.003	0.010	0.000	0.003	0.000	0.000	0.000	0.000
3	0.189	0.561	0.014	0.000	0.000	0.027	0.041	0.000	0.027	0.000	0.000	0.000	0.000
5	0.140	0.116	0.098	0.007	0.004	0.014	0.042	0.000	0.000	0.000	0.021	0.014	0.000
8	0.037	0.447	0.000	0.011	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
35	0.239	0.157	0.258	0.022	0.013	0.000	0.000	0.003	0.000	0.000	0.000	0.069	0.000
36	0.185	0.018	0.328	0.015	0.030	0.021	0.000	0.003	0.000	0.000	0.100	0.033	0.000
37	0.029	0.333	0.196	0.058	0.042	0.000	0.000	0.000	0.000	0.004	0.017	0.029	0.000
79	0.026	0.022	0.143	0.000	0.026	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.000
90	0.060	0.138	0.130	0.035	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
92	0.006	0.197	0.151	0.137	0.018	0.000	0.037	0.000	0.002	0.000	0.023	0.000	0.000
93	0.055	0.030	0.184	0.000	0.050	0.000	0.000	0.000	0.000	0.000	0.015	0.010	0.000
Lowland mean	0.172	0.085	0.014	0.002	0.004	0.024	0.018	0.005	0.022	0.000	0.001	0.001	0.000
stddev	0.054	0.024	0.006	0.001	0.004	0.013	0.008	0.003	0.012	0.000	0.001	0.001	0.000
Upland mean	0.088	0.174	0.154	0.024	0.021	0.006	0.012	0.001	0.003	0.001	0.022	0.017	0.000
stddev	0.024	0.054	0.034	0.012	0.005	0.003	0.005	0.000	0.002	0.001	0.010	0.007	0.000

Table 18b. Relative abundances of most common taxa, except Chironomidae and Oligochaeta, collected from the SRP sites.

Stream	Baetis	Elmidae	Heptageniidae	Zapada	Rhyacophilidae	Brachycentrus	Ephemerella	Hexatoma	Hyallela	Capnia	Drunella	Turbellaria	Sialis
Snake River Plain - Lowland Sites													
15	0.000	0.244	0.011	0.095	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
16	0.007	0.214	0.014	0.000	0.000	0.014	0.000	0.021	0.000	0.000	0.000	0.000	0.024
17	0.202	0.124	0.025	0.127	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009
26	0.053	0.018	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	0.021	0.122	0.112	0.000	0.000	0.000	0.000	0.017	0.000	0.000	0.000	0.000	0.028
29	0.079	0.021	0.000	0.003	0.000	0.000	0.000	0.000	0.034	0.000	0.000	0.000	0.000
32	0.120	0.074	0.011	0.000	0.000	0.000	0.117	0.000	0.021	0.000	0.000	0.004	0.000
44	0.095	0.434	0.014	0.000	0.000	0.000	0.000	0.019	0.000	0.005	0.000	0.019	0.000
45	0.097	0.051	0.008	0.000	0.000	0.054	0.019	0.183	0.000	0.000	0.004	0.004	0.000
46	0.173	0.130	0.035	0.000	0.028	0.046	0.000	0.158	0.000	0.000	0.000	0.000	0.000
47	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.133
48	0.000	0.088	0.044	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.012
51	0.006	0.003	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000
52	0.517	0.014	0.066	0.000	0.000	0.003	0.028	0.059	0.000	0.000	0.003	0.007	0.000
53	0.446	0.083	0.000	0.080	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000
63	0.352	0.022	0.000	0.000	0.011	0.011	0.000	0.000	0.055	0.000	0.000	0.000	0.000
70	0.097	0.110	0.000	0.177	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
72	0.170	0.001	0.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Snake River Plain - Upland Sites													
4	0.206	0.329	0.213	0.000	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000
38	0.111	0.003	0.120	0.018	0.084	0.000	0.000	0.006	0.000	0.129	0.006	0.024	0.000
39	0.036	0.004	0.062	0.000	0.004	0.000	0.000	0.004	0.004	0.000	0.036	0.000	0.000
40	0.082	0.019	0.165	0.051	0.019	0.003	0.000	0.009	0.000	0.000	0.006	0.008	0.000
41	0.013	0.003	0.050	0.050	0.067	0.000	0.003	0.020	0.000	0.020	0.084	0.023	0.000
42	0.122	0.016	0.067	0.016	0.047	0.000	0.008	0.000	0.000	0.012	0.039	0.067	0.000
43	0.047	0.024	0.189	0.027	0.051	0.000	0.000	0.007	0.000	0.003	0.003	0.007	0.000
80	0.007	0.000	0.014	0.000	0.157	0.000	0.000	0.000	0.000	0.347	0.002	0.034	0.000
88	0.059	0.244	0.001	0.000	0.008	0.004	0.000	0.000	0.000	0.000	0.008	0.004	0.000
89	0.034	0.260	0.097	0.011	0.001	0.008	0.000	0.000	0.000	0.000	0.005	0.038	0.000
Lowland mean	0.135	0.097	0.020	0.027	0.003	0.007	0.009	0.026	0.006	0.000	0.000	0.002	0.012
stddev	0.036	0.026	0.007	0.013	0.002	0.004	0.006	0.013	0.004	0.000	0.000	0.001	0.007
Upland mean	0.072	0.090	0.098	0.017	0.044	0.002	0.001	0.005	0.000	0.051	0.019	0.020	0.000
stddev	0.018	0.039	0.022	0.006	0.015	0.001	0.001	0.002	0.000	0.033	0.008	0.006	0.000

Drunella, and Turbellaria (Fig. 11, Table 19). Axis-2 had two taxonomic groups similar among ecoregions (*Brachycentrus* and *Hexatoma*), while the *Ephemerella* and the amphipod *Hyallela azteca* also were important for distinguishing NBR sites and the shredder *Zapada* was important for distinguishing among sites in the SRP ecoregion (Fig. 11). Not shown by multivariate analysis was the greater abundance of *Baetis* in lowland sites for both ecoregions suggesting that this taxa may exhibit a high degree of resistance to degraded habitat conditions (Table 18a,b).

MDA results displayed patterns similar to the PCA, emphasizing the predominance of Heptageniidae and Rhyacophilidae in upland sites for either ecoregion (Fig. 12). As with the macroinvertebrate metrics, taxonomic differences were evident between NBR and SRP lowland sites, primarily associated with abundances of *Hexatoma* and *Tricorythodes*. Additional within-ecoregion analyses, based on MDA (Fig. 13), revealed differences in Oligochaeta and Chironomidae abundances among lowland and upland sites in the NBR. These analyses also revealed differences in abundances of Oligochaeta, Elmidae, *Hydropsyche,* and *Zapada* among lowland and upland sites of the SRP ecoregion (Table 18a,b).

Based on the multivariate results (PCA and MDA), metric scores were derived for the Heptageniidae and Rhyacophilidae for each ecoregion and included with the macroinvertebrate score (Tables 20, 21). This modified score resulted in an average metric score of 20 for lowland and 40 for upland sites in the NBR and scores of 21 and 28, respectively in the SRP (Figs. 14, 15). The addition of these taxonomic groups as metrics greatly improved the resolution of the macroinvertebrate metric score as evidenced by the major increase in correlation coefficients (r^2 values) for the regression against the habitat assessment score (Figs. 14, 15).

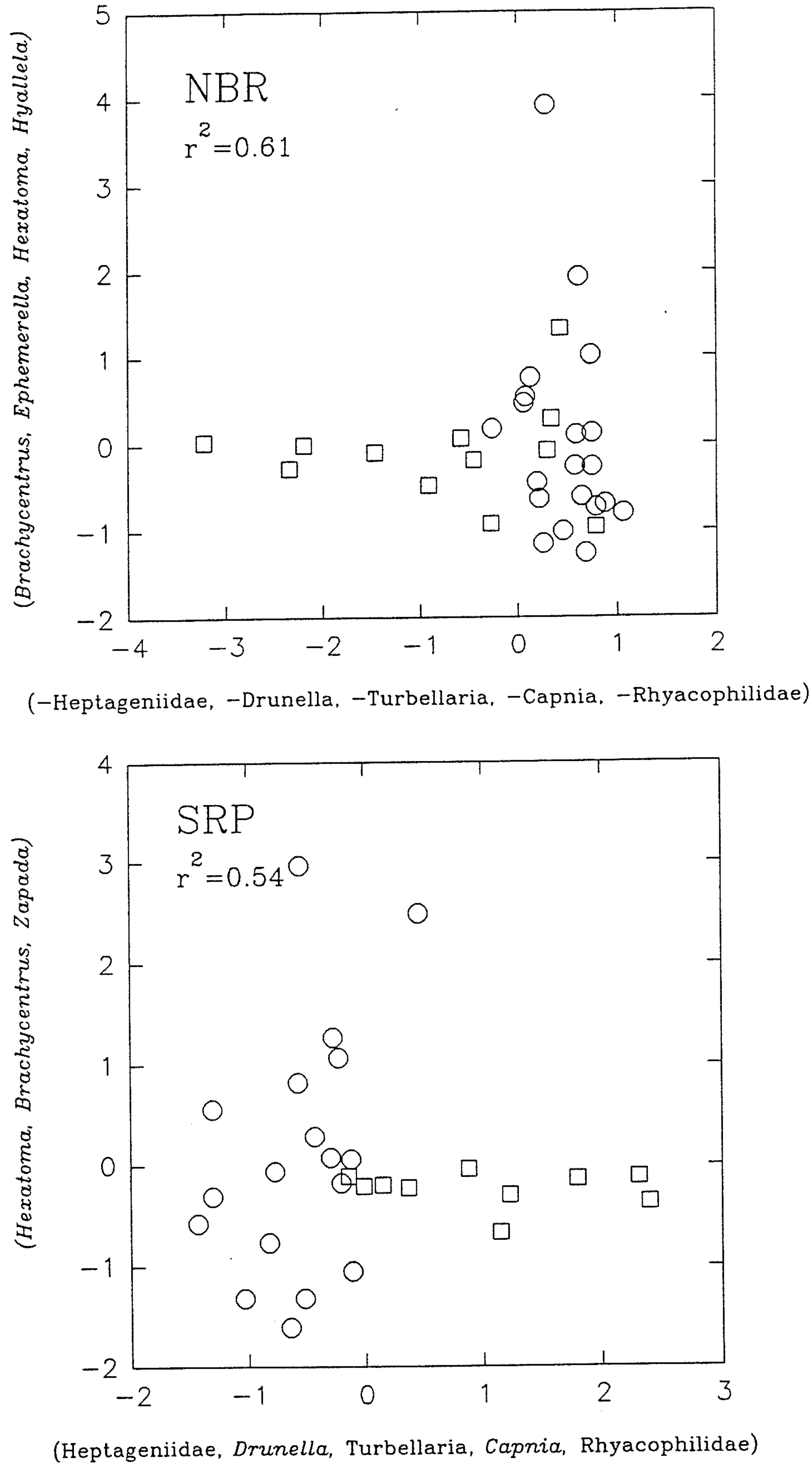


Fig. 11. Scattergram of PCA results based on the relative abundances of the 20 most abundant taxa for each ecoregion. Circles represent lowland and squares upland sites.

Table 19. Factors scores from PCA results based on the relative abundances of the 20 most abundant macroinvertebrate taxa.

TAXA	NBR		SRP	
	FACTOR-1	FACTOR-2	FACTOR-1	FACTOR-2
Heptagenidae	-.868	-.110	.518	.077
Turbellaria	-.837	.021	.702	-.018
Drunella	-.831	-.038	.591	-.018
Capnia	-.725	-.021	.747	-.102
Rhyacophila	-.659	-.097	.912	-.022
Zapada	-.477	-.168	.133	-.580
Hydracarina	-.325	.408	.462	.227
Elmidae	-.143	.113	-.221	.017
Suwallia	-.034	-.179	-.275	.223
Hexatoma	-.012	.668	.101	.833
Brachycentrus	.016	.745	-.093	.808
Ostracoda	.046	.344	-.321	.304
Hydropsyche	.048	-.002	-.279	.069
Simuliidae	.050	.044	-.471	-.322
Baetis	.061	.225	-.187	.169
Ephemerella	.182	.757	-.182	.361
Oligochaeta	.223	-.459	.163	-.205
Hyallela	.276	.637	-.274	.151
Tricorythodes	.311	-.141	-.428	-.031
Chironomidae	.343	-.305	-.039	.139

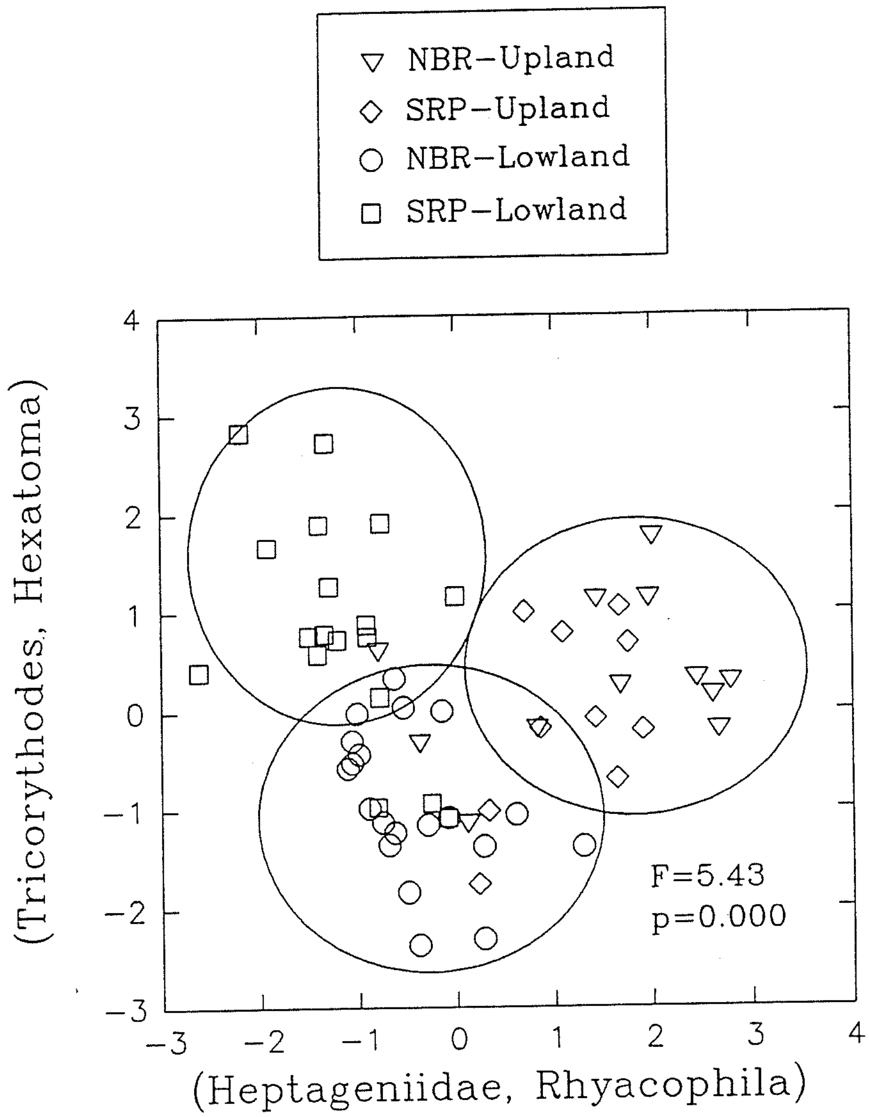


Fig. 12. Scattergram from MDA results based on the top 20 most abundant macroinvertebrate taxa. See text for further explanation. Circles fitted by eye to denote major groupings.

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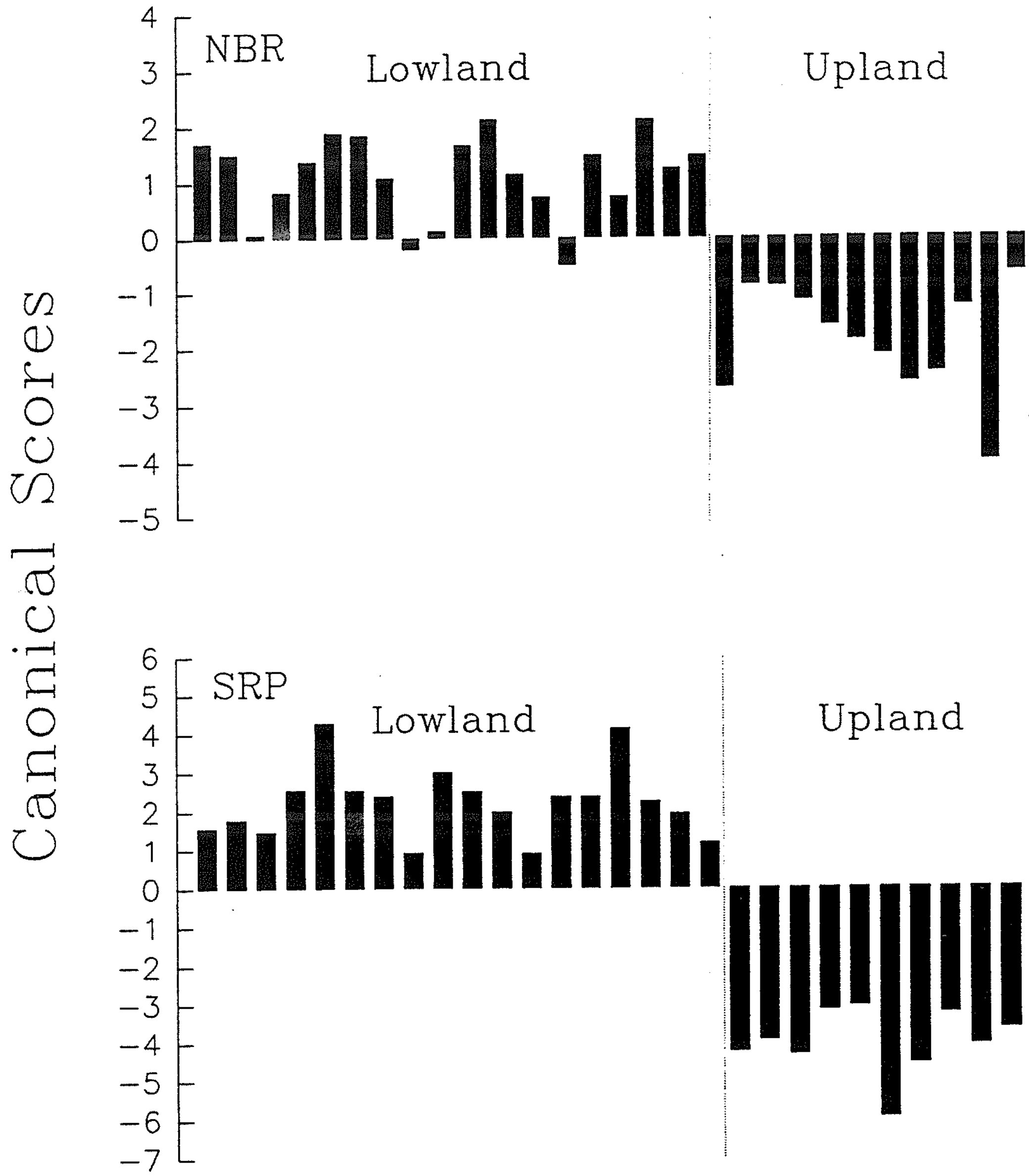

Fig. 13. Canonical scores from multiple discriminant analysis based on the relative abundance of the top 20 most abundant macroinvertebrate taxa found at sites within each ecoregion. Data transformed prior to analysis with each bar representing a sample site. within a respective ecoregion.

Table 20. Absolute values and assigned scores for macroinvertebrate metrics for streams in the NBR ecoregion. Scores summed based on PCA + MDA results for biotic metrics and taxonomic analyses. Note: SC equals SCORE.

STREAM	EPT/ (CHIR+OLIG)	SC	SPECIES RICHNESS	SC	EPT RICHNESS	SC	HBI INDEX	SC	EPT/ CHIRONOMID	SC	% DOMINANCE	SC	H' DIVERSITY	SC	SIMPSON'S INDEX	SC	% CHIR+OLIG	SC	% CHIRONOMID	SC	% HEPTAGENIIDAE	SC	% RHYACOPHILIDAE	SC	PCA SCORE	PCA+TAXA SCORE
Lowland Sites																										
	1.8	1	19	3	7	1	4.49	1	2.0	1	0.18	5	2.37	3	0.12	5	0.18	3	0.16	3	0.003	1	0.000	1	26	28
19	4.3	3	18	1	7	1	4.93	1	25.5	5	0.29	3	2.35	3	0.13	5	0.12	3	0.02	5	0.000	1	0.000	1	30	32
28	0.8	1	18	1	9	1	4.29	3	1.0	1	0.32	3	2.11	3	0.18	3	0.37	1	0.32	1	0.004	1	0.069	5	18	24
31	9.8	3	18	1	8	1	3.26	5	11.9	3	0.28	3	2.09	3	0.17	3	0.06	5	0.05	5	0.004	1	0.000	1	32	34
49	0.3	1	11	1	3	1	5.20	1	0.8	1	0.40	3	1.48	1	0.28	1	0.69	1	0.29	1	0.048	1	0.000	1	12	14
50	34.4	5	19	3	9	1	4.43	1	39.3	5	0.69	1	1.36	1	0.46	1	0.03	5	0.02	5	0.000	1	0.009	1	28	30
60	0.2	1	16	1	5	1	5.57	1	0.2	1	0.53	1	1.39	1	0.35	1	0.65	1	0.53	1	0.000	1	0.000	1	10	12
61	0.2	1	11	1	3	1	6.49	1	0.3	1	0.34	3	1.79	1	0.21	1	0.59	1	0.34	1	0.000	1	0.000	1	12	14
62	0.5	1	17	1	4	1	5.20	1	6.8	3	0.29	3	2.22	3	0.16	3	0.32	1	0.02	5	0.098	3	0.000	1	22	26
64	65.4	5	22	3	11	3	5.25	1	84.3	5	0.74	1	1.13	1	0.56	1	0.00	5	0.00	5	0.043	1	0.000	1	30	32
65	0.0	1	16	1	7	1	5.68	1	0.0	1	0.75	1	0.94	1	0.59	1	0.88	1	0.75	1	0.000	1	0.000	1	10	12
66	0.0	1	7	1	2	1	5.32	1	0.1	1	0.68	1	0.86	1	0.53	1	0.94	1	0.26	1	0.000	1	0.000	1	10	12
67	0.1	1	16	1	7	1	5.35	1	0.2	1	0.55	1	1.48	1	0.35	1	0.75	1	0.55	1	0.024	1	0.000	1	10	12
68	0.8	1	22	3	14	3	5.04	1	0.8	1	0.41	3	1.63	1	0.28	1	0.43	1	0.41	1	0.011	1	0.004	1	16	18
69	0.1	1	17	1	5	1	5.66	1	0.1	1	0.57	1	1.60	1	0.36	1	0.57	1	0.57	1	0.000	1	0.000	1	10	12
71	0.0	1	10	1	0	1	5.48	1	0.0	1	0.80	1	0.89	1	0.64	1	0.85	1	0.06	3	0.000	1	0.000	1	12	14
73	42.4	5	13	1	6	1	4.77	1	42.9	5	0.86	1	0.64	1	0.75	1	0.02	5	0.02	5	0.000	1	0.000	1	26	28
85	0.3	1	11	1	2	1	5.92	1	0.4	1	0.48	1	1.45	1	0.31	1	0.62	1	0.48	1	0.000	1	0.000	1	10	12
86	0.4	1	9	1	4	1	5.47	1	0.4	1	0.65	1	1.05	1	0.46	1	0.65	1	0.65	1	0.000	1	0.000	1	10	12
94	0.5	1	21	3	9	1	4.47	1	0.6	1	0.37	3	2.10	3	0.20	3	0.27	1	0.19	1	0.045	1	0.000	1	18	20
Upland Sites																										
1	7.3	3	31	5	21	5	3.28	5	7.6	3	0.20	5	2.71	5	0.10	5	0.09	3	0.08	3	0.329	5	0.027	5	42	52
2	3.5	3	11	1	7	1	3.04	5	3.5	1	0.92	1	0.45	1	0.85	1	0.01	5	0.01	5	0.016	1	0.000	1	24	26
3	24.3	5	21	3	10	1	4.18	3	32.3	5	0.56	1	1.67	1	0.36	1	0.01	5	0.01	5	0.014	1	0.000	1	30	32
5	1.3	1	22	3	16	5	4.41	1	1.3	1	0.36	3	2.21	3	0.18	3	0.36	1	0.36	1	0.098	3	0.004	1	22	26
8	1.6	1	17	1	10	1	4.24	3	1.6	1	0.45	3	1.85	3	0.25	1	0.18	3	0.17	1	0.000	1	0.007	1	18	20
35	10.4	5	19	3	9	1	4.14	3	12.5	3	0.26	5	2.08	3	0.17	3	0.06	5	0.05	5	0.258	5	0.013	3	38	44
36	10.8	5	25	5	15	5	3.36	5	22.5	5	0.26	5	2.50	5	0.13	5	0.07	5	0.03	5	0.328	5	0.030	5	50	60
37	3.5	3	26	5	17	5	3.74	5	4.5	1	0.28	3	2.57	5	0.13	5	0.12	3	0.09	3	0.196	5	0.042	5	38	48
79	2.0	1	22	3	11	3	5.42	1	2.1	1	0.41	3	2.04	3	0.22	1	0.17	3	0.16	3	0.143	3	0.026	5	22	30
90	2.3	1	22	3	12	3	3.55	5	14.9	3	0.18	5	2.75	5	0.09	5	0.21	1	0.03	5	0.130	3	0.035	5	36	44
92	15.0	5	21	3	12	3	3.72	5	37.5	5	0.16	5	2.44	5	0.11	5	0.04	5	0.02	5	0.151	5	0.018	3	46	54
93	0.9	1	23	3	12	3	4.72	1	1.3	1	0.28	3	2.35	3	0.14	3	0.40	1	0.28	1	0.184	5	0.050	5	20	30
Lowland mean	8.1		15.6		6.1		5.11		10.9		0.51		1.55		0.36		0.45		0.29		0.014		0.004		17.60	19.90
stderr	4.0		1.0		0.8		0.16		4.9		0.04		0.12		0.04		0.07		0.05		0.006		0.004		1.81	1.94
Upland mean	6.9		21.8		12.7		3.98		11.8		0.36		2.13		0.17		0.14		0.11		0.154		0.021		32.00	38.83
stderr	2.0		1.4		1.1		0.19		3.5		0.06		0.17		0.02		0.04		0.03		0.034		0.005		3.25	3.91
mean-cl90%	3.4		19.3		10.7		3.65		5.5		0.26		1.82		0.13		0.08		0.05		0.093		0.012			
mean+cl90%	10.5		24.4		14.6		4.32		18.1		0.47		2.45		0.21		0.21		0.17							
SCORE																										
5	> 10.5		> 24.4		> 14.6		<3.7		> 18.1		<.26		> 2.45		<.13		<.08		<.05		>.154		>.021			
3	3.4-10.5		19-24.4		10.7-14.6		3.7-4.3		5.5-18.1		.26-.47		1.82-2.45		.13-.21		.08-.21		.05-.17		.09-.154		.012-.021			
1	<3.4		<19		<10.7		>4.3		<5.5		>.47		<1.82		>.21		>.21		>.17		<.093		<.012			

Table 21. Absolute values and assigned scores for macroinvertebrate metrics for streams in the SRP ecoregion. Scores summed based on PCA + MDA results for biotic metrics and taxonomic analyses. Note: SC equals SCORE.

STREAM	SPECIES RICHNESS	SC	EPT RICHNESS	SC	% DOMINANCE	SC	H' DIVERSITY	SC	SIMPSON'S INDEX	SC	SCRAPERS/ FILTERERS	SC	% SCRAPERS	SC	% HEPTAGENIIDAE	SC	% RHYACOPHILIDAE	SC	PCA SCORE (F1+F2)	PCA+TAXA SCORE
Lowland Sites																				
15	20	3	10	3	0.22	5	2.45	5	0.11	5	1.53	1	0.10	1	0.011	1	0.000	1	23	25
16	30	5	10	3	0.39	3	2.24	3	0.21	3	2.00	1	0.06	1	0.014	1	0.000	1	19	21
17	24	5	12	3	0.29	5	2.23	3	0.16	5	11.88	3	0.30	5	0.025	1	0.006	1	29	31
26	16	1	6	1	0.48	1	1.62	1	0.31	1	0.18	1	0.09	1	0.011	1	0.000	1	7	9
27	21	3	9	1	0.21	5	2.44	5	0.12	5	0.75	1	0.15	3	0.112	5	0.000	1	23	29
29	24	5	9	1	0.38	3	2.22	3	0.19	3	1.19	1	0.15	3	0.000	1	0.000	1	19	21
32	23	5	8	1	0.12	5	2.73	5	0.08	5	0.90	1	0.20	3	0.011	1	0.000	1	25	27
44	21	3	9	1	0.43	3	1.99	3	0.23	3	3.08	1	0.11	1	0.014	1	0.000	1	15	17
45	22	3	12	3	0.21	5	2.48	5	0.12	5	3.29	1	0.18	3	0.008	1	0.000	1	25	27
46	23	5	12	3	0.22	5	2.33	5	0.13	5	4.00	3	0.21	3	0.035	1	0.028	3	29	33
47	8	1	2	1	0.69	1	1.05	1	0.51	1	0.00	1	0.00	1	0.000	1	0.000	1	7	9
48	19	3	9	1	0.40	3	2.18	3	0.19	3	1.80	1	0.05	1	0.044	1	0.000	1	15	17
51	10	1	4	1	0.30	3	1.68	1	0.22	3	0.05	1	0.01	1	0.000	1	0.000	1	11	13
52	19	3	10	3	0.52	1	1.66	1	0.32	1	34.00	5	0.59	5	0.066	3	0.000	1	19	23
53	14	1	5	1	0.45	1	1.52	1	0.30	1	1.48	1	0.45	5	0.000	1	0.000	1	11	13
63	20	3	6	1	0.35	3	2.02	3	0.23	3	33.00	5	0.36	5	0.000	1	0.011	1	23	25
70	15	1	4	1	0.31	3	2.10	3	0.17	3	1.79	1	0.10	1	0.000	1	0.000	1	13	15
72	12	1	6	1	0.34	3	1.78	1	0.21	3	0.55	1	0.19	3	0.016	1	0.000	1	13	15
Upland Sites																				
4	17	1	10	3	0.33	3	1.91	3	0.21	3	6.40	3	0.46	5	0.213	5	0.004	1	21	27
38	22	3	12	3	0.14	5	2.56	5	0.10	5	0.00	1	0.24	3	0.120	5	0.084	5	25	35
39	21	3	13	3	0.71	1	1.34	1	0.51	1	44.00	5	0.16	3	0.062	3	0.004	1	17	21
40	24	5	16	5	0.27	5	2.36	5	0.14	5	13.50	3	0.26	3	0.165	5	0.019	3	31	39
41	24	5	17	5	0.25	5	2.52	5	0.12	5	2.21	1	0.21	3	0.050	1	0.067	5	29	35
42	24	5	18	5	0.49	1	2.06	3	0.27	3	21.33	5	0.25	3	0.067	3	0.047	5	25	33
43	27	5	16	5	0.32	3	2.43	5	0.15	5	8.88	3	0.24	3	0.189	5	0.051	5	29	39
80	12	1	5	1	0.36	3	1.54	1	0.28	3	0.00	1	0.02	1	0.014	1	0.157	5	11	17
88	18	3	7	1	0.38	3	1.81	3	0.23	3	4.29	3	0.07	1	0.001	1	0.008	1	17	19
89	17	1	9	1	0.42	3	1.78	1	0.26	3	7.14	3	0.14	1	0.097	5	0.001	1	13	19
Lowland mean	18.94		7.94		0.35		2.04		0.21		5.64		0.18		0.020		0.003		18.11	20.56
stderr	1.24		0.67		0.03		0.09		0.02		2.34		0.03		0.007		0.002		1.60	1.71
Upland mean	20.60		12.30		0.37		2.03		0.23		10.78		0.20		0.098		0.044		21.80	28.40
stderr	1.36		1.34		0.05		0.13		0.04		4.01		0.04		0.022		0.015		2.12	2.61
mean-cl90%	18.11		9.84		0.28		1.80		0.16		3.42		0.14		0.059		0.018			
mean+cl90%	23.09		14.76		0.45		2.26		0.29		18.13		0.27							
SCORE																				
5	>23		>14.8		<.28		>2.26		<.16		>18.1		>.27		>.098		>.044			
3	18-23		9.8-14.8		.28-.45		1.8-2.26		.16-.29		3.4-18.1		.14-.27		.06-.098		.018-.044			
1	<18		<9.8		>.45		<1.8		>.29		<3.4		<.14		<.06		<.018			

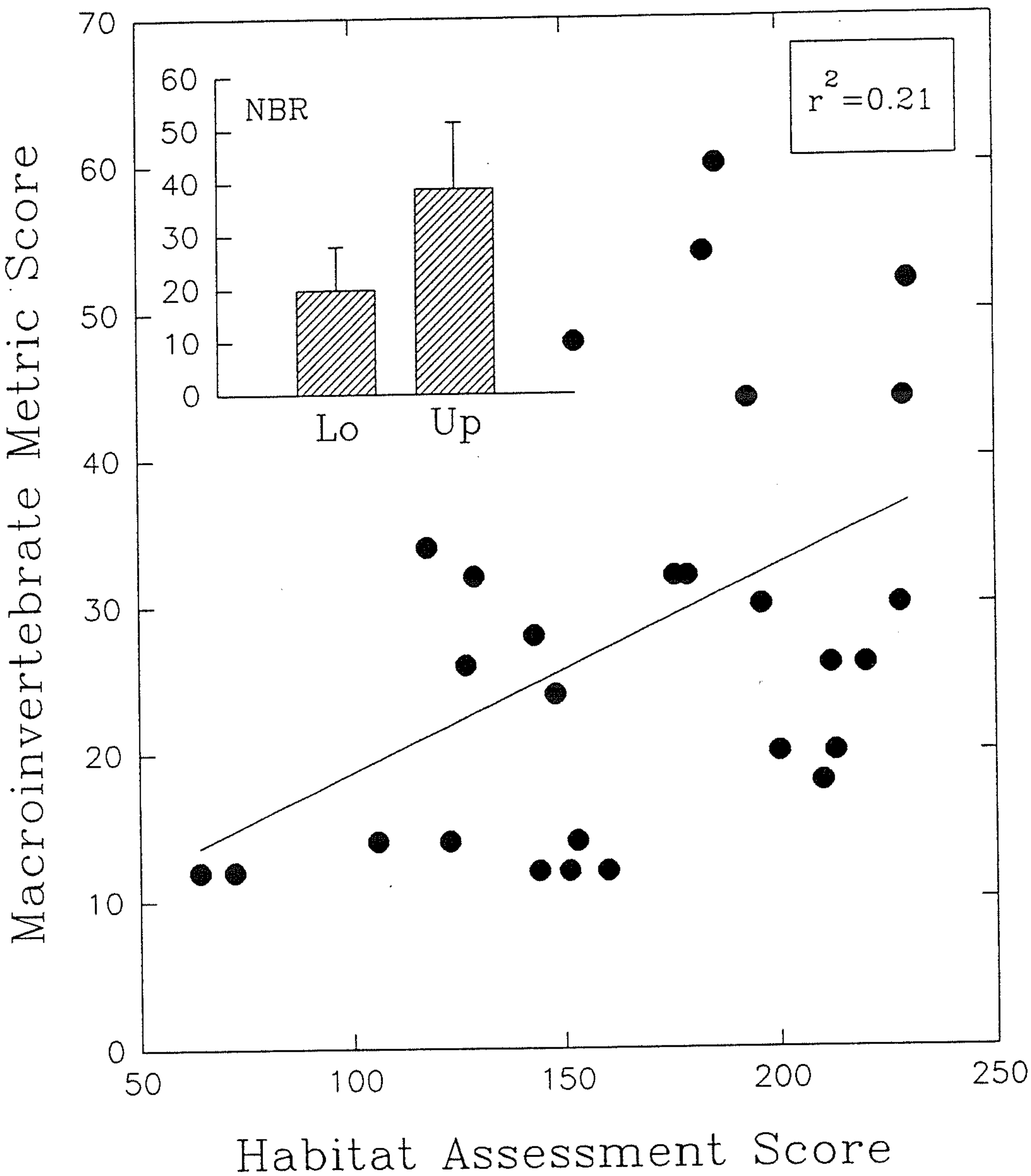

Fig. 14. Regression of NBR macroinvertebrate metric score with taxonomic metrics included against the NBR habitat assessment score. Inset reflects average macroinvertebrate metric score for upland and lowland scores; error bars equal +1 standard deviation from the mean, n=19 and 13 for lowland and upland sites, respectively.

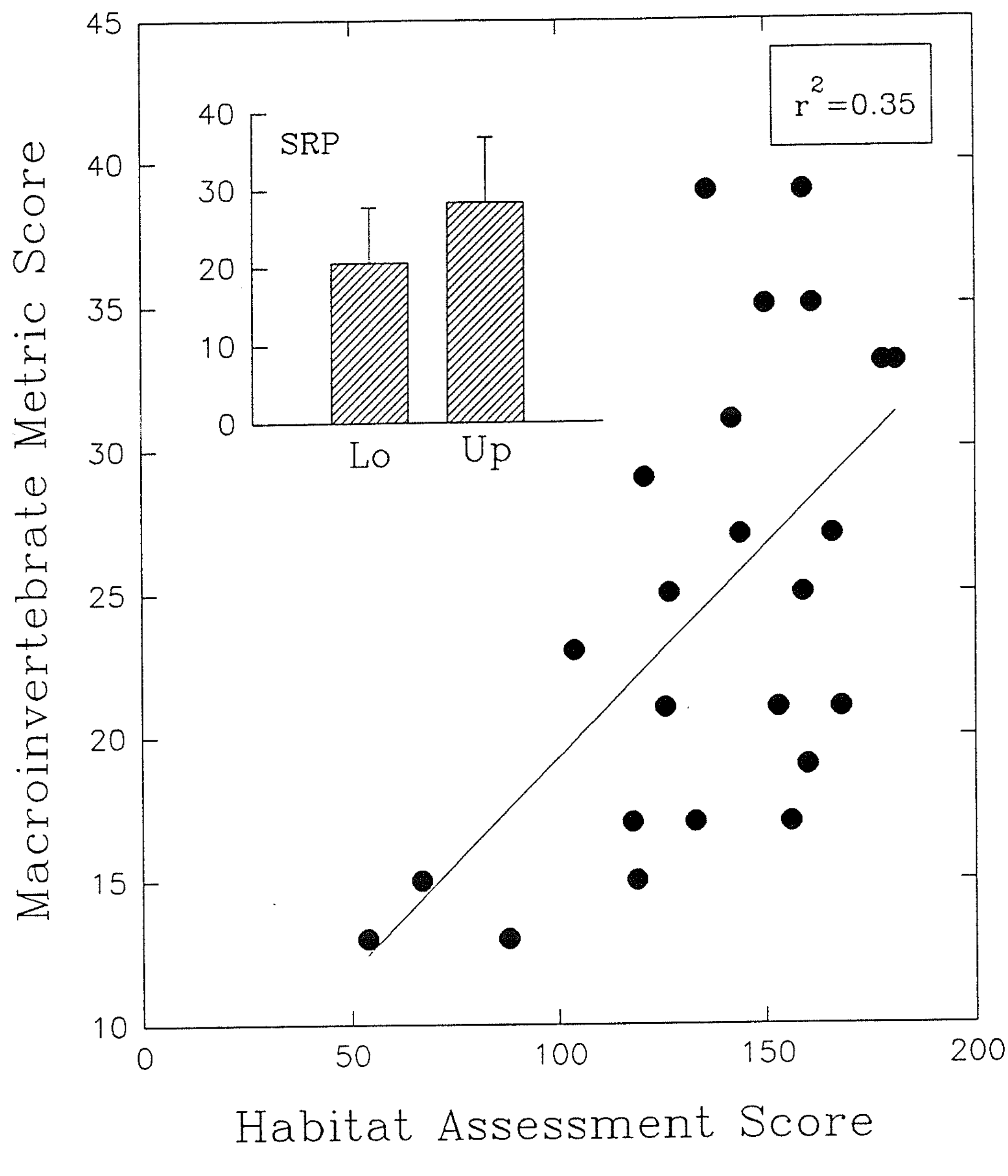

Fig. 15. Regression of SRP macroinvertebrate metric score with taxonomic metrics included against the SRP habitat assessment score. Inset reflects average macroinvertebrate metric score for upland and lowland scores; error bars equal +1 standard deviation from the mean, n=18 and 10 for lowland and upland sites, respectively.

Fish Metrics for NBR and SRP

Tables 22 and 23 provide the basic data for fish species collected from each site, and designations of fish taxa for tolerance, trophic guild, and whether native or introduced (Chandler and Maret 1993). Evident from this table, and the analyses below, is the shift from a relatively intolerant Salmonidae-based system in upland streams to a tolerant non-Salmonidae based system in lowland streams. For example, Rainbow and especially, Brook Trout were more abundant in upland than in lowland sites, whereas Redside Shiners, suckers, and dace were more abundant in lowland than in upland streams for both ecoregions. The condition factor of Salmonidae also was higher in upland streams than lowland streams. Species richness tended to be higher in lowland streams than in upland streams, probably reflecting more optimal temperatures (higher) for non-salmonids such as dace, suckers, and shiners. Thus, species richness makes a poor metric for fish in temperate, montane ecoregions.

The fish metric data are summarized in Tables 24 and 25 for each ecoregion. An assigned score of five indicated optimal conditions for a particular metric. Principal components analysis and multiple discriminant analysis agreed closely on seven important fish metrics to distinguish among stream types within ecoregions. The first two axes of the PCA explained 90% and 93% of the variation among sites for NBR and SRP ecoregions, respectively. Because of the rather depauperate species richness of temperate mountain streams, important metrics were based primarily on the presence or absence of Salmonidae, and most metrics were highly correlated (Table 26a,b). For example, only 14 species of fish were collected among all sites with an average of only 1 to 3 species collected per site. Further, the same metrics were found important for both ecoregions. The summed fish metric score for upland streams averaged 26 (NBR) and 30 (SRP), whereas lowland scores averaged 20 and 18, respectively (Tables 24, 25; Figs. 16, 17). The fish metric score showed a significant positive regression against the habitat assessment score (r^2=0.41, NBR; r^2=0.40, SRP).

Table 22. Number of fish tallied from NBR study sites with respective Native/Introduced (N=Native, I=Introduced), Tolerance (I=intolerant, MI=moderately intolerant, MT=moderately tolerant, T=tolerant); Trophic Guild (I=Insectivore, C=Carnivore, H=Herbivore, O=Omnivore) designations.

	#	DATE	RAINBOW TROUT	BROOK TROUT	CUTTHROAT TROUT	BROWN TROUT	BULL TROUT	REDSIDE SHINER	MOUNTAIN SUCKER	BLUEHEAD SUCKER	LONGNOSE SUCKER	MOTTLED SCULPIN	PAIUTE SCULPIN	WD-RIVER SCULPIN	SPECKLED DACE	LONGNOSE DACE
TOLERANCE*			I	MI	I	MI	I	MI/MT	MT	MT	MT	MI	I	I	MI/MT	MI/MT
TROPHIC GUILD*			I/C	I/C	I/C	I/C	I/C	I	H	I	I	I	I	I	I	I
NATIVE/INTRODUCED*			I	I	N	I	N	N	N	N	N	N	N	N	N	N
Northern Basin and Range - Lowland Sites																
Wright	73	930710														
Slug	71	930708														
Up Portneuf	69	930710	1												11	20
Pearl	68	930709		4								10				
Lanes	67	930710														4
Crow	65	930717							8			4			1	
Clyde	64	930710		10								1				
Chippy	62	930715	1												1	2
Angus (up)	61	930710						5	5						7	
Angus (low)	60	930710						1			10	1				
Wolverine	50	910627			16											
SF Mink	49	910627														
Trapper	31	900621	2													4
Cassia	28	900618	1					11				47				2
Station	19	900613	9			4						6	5			
Lake Fork	18	900613	2					5					2			
Rock (Holbrook)	86	930715														8
Pebble	85	930708										5				
Kelsaw	66	930711														
Northern Basin and Range - Upland Sites																
Bell Marsh	93	930708			4											
Walker	92	930708			16											
Toponce	90	930715	4													
Green (Inkom)	79	930707	2													
WF Mink	37	910627			3											
Mink	36	910629		54												
Bloomington	35	910629	1													
3rd Fork	8	900717	42													
Cottonwood	5	900614	13	10	1								9			
Trapper	3	900615	12										1			
Stinson	2	900614		8												
Green	1	900614	1	10												

Table 23. Number of fish tallied from SRP study sites with respective Native/Introduced (N=Native, I=Introduced), Tolerance (I=Intolerant, MI=moderately intolerant, MT=moderately tolerant, T=tolerant); Trophic Guild (I=Insectivore, C=Carnivore, H=Herbivore, O=Omnivore) designations.

	#	DATE	RAINBOW TROUT	BROOK TROUT	CUTTHROAT TROUT	BROWN TROUT	BULL TROUT	REDSIDE SHINER	MOUNTAIN SUCKER	BLUEHEAD SUCKER	LONGNOSE SUCKER	MOTTLED SCULPIN	PAIUTE SCULPIN	WD-RIVER SCULPIN	SPECKLED DACE	LONGNOSE DACE	CHISELMOUTH	SMALLMOUTH BASS
TOLERANCE*			I	MI	I	MI	I	MI/MT	MT	MT	MT	MI	I	I	MI/MT	MI/MT	T	MI/MT
TROPHIC GUILD*			I/C	I/C	I/C	I/C	I/C	I	H	I	I	I	I	I	I	I	O	C
NATIVE/INTRODUCED*			I	I	N	I	N	N	N	N	N	N	N	N	N	N	N	I
Snake River Plain - Lowland Sites																		
Willow	72	930724							1			1						
Shoofly	70	930723	2															
Clover	63	930724													1			
Rock (Magic)	53	910623	3									4						
Deep	52	910621	5					171	90			1			300			
Camas	51	910623						55	4						8			
Spring	48	910625	76					18	21						147			
Duncan	47	910622	39															
Current	46	910621										4			1			
Cold Springs	45	910623	18												3			
Big Willow	44	910624	17					1	5						46			
Shoshone	32	900619						31		20		2			3		2	1
Mary's	29	900720						24								5		
Big Jack	27	900619	5					17	35						34			
Sheep	26	900620						19							19			
Cottonwood	17	900826	9															
Big Jack	16	900825	3					55	12							42		
Little Jack	15	900721	10									11						
Snake River Plain - Upland Sites																		
Squaw	89	930719		10														
Soldier	88	930723		19										2				
Iron	80	930720					2											
Coyote	43	910801		1								5						
Ramey	42	910830		2														
Bear	41	910830		6														
Cherry	40	910801										12						
SF Soldier	39	910624		5										5				
Timber	38	910829					22											
Buck	4	900620	7															

Table 24. Absolute values and respective scores for fish metrics for streams in NBR ecoregion. Scores totaled based on results from PCA and all metrics combined. Note: SC equals SCORE.

TYPE	STRM	SPECIES RICHNESS	SC	NATIVE RICHNESS	SC	INTRO SPECIES	SC	SALMONID RICHNESS	SC	BENTHIC RICHNESS	SC	INTOLER RICHNESS	SC	% INTRODUCED	SC	% CARNIVORES	SC	% INVERTIVORES	SC	% SALMONIDAE	SC	DENSITY (No./m2)	SC	BIOMASS (g/m2)	SC	SALMONID DENSITY	SC	SALMONID BIOMASS	SC	CONDITION FACTOR	SC	PCA SCORE	TOTAL SCORE
Lowland Sites																															
	50	1	3	1	5	1	3	1	3	0	1	1	3	0.000	5	1.000	5	1.000	5	1.000	5	0.133	5	3.37	3	0.133	5	3.37	3	1.21	3	27	57
	68	2	5	1	5	1	3	1	3	1	5	2	5	0.286	5	1.000	5	1.000	5	0.286	1	0.077	3	1.86	3	0.022	1	1.54	3	1.72	5	31	57
	64	2	5	1	5	1	3	1	3	1	5	2	5	0.909	1	1.000	5	1.000	5	0.909	5	0.046	1	2.22	3	0.042	1	2.16	3	1.49	5	35	55
	19	4	5	2	5	2	1	2	5	2	5	2	5	0.542	3	1.000	5	1.000	5	0.542	1	0.082	3	2.52	3	0.044	1	2.32	3	0.95	3	29	53
	28	4	5	3	5	1	3	1	3	2	5	1	3	0.016	5	0.787	3	0.787	3	0.016	1	0.152	5	1.67	3	0.002	1	0.72	1	1.02	3	25	49
	18	3	5	2	5	1	3	1	3	1	5	1	3	0.222	5	0.444	1	0.444	1	0.222	1	0.231	5	0.70	1	0.051	3	0.46	1	0.85	1	19	43
	85	1	3	1	5	0	5	0	1	1	5	1	3	0.000	5	1.000	5	1.000	5	0.000	1	0.011	1	0.06	1	0.000	1	0.00	1	0.00	1	25	43
	94	4	5	2	5	3	1	3	5	0	1	2	5	0.708	3	0.833	3	0.833	3	0.833	3	0.048	1	1.15	1	0.040	1	1.15	1	1.42	5	25	43
	31	2	5	1	5	1	3	1	3	1	5	0	1	0.333	5	0.333	1	0.333	1	0.333	1	0.030	1	2.26	3	0.010	1	1.98	3	1.05	3	21	41
	61	3	5	3	5	0	5	0	1	1	5	0	1	0.000	5	0.000	1	0.000	1	0.000	1	0.162	5	0.92	1	0.000	1	0.00	1	0.00	1	19	39
	65	3	5	3	5	0	5	0	1	2	5	1	3	0.000	5	0.308	1	0.308	1	0.000	1	0.064	3	0.43	1	0.000	1	0.00	1	0.00	1	19	39
	60	3	5	3	5	0	5	0	1	1	5	1	3	0.000	5	0.083	1	0.083	1	0.000	1	0.048	1	0.63	1	0.000	1	0.00	1	0.00	1	19	37
	69	3	5	2	5	1	3	1	3	2	5	0	1	0.031	5	0.031	1	0.031	1	0.031	1	0.106	3	0.27	1	0.003	1	0.00	1	0.00	1	19	37
	62	3	5	2	5	1	3	1	3	2	5	0	1	0.250	5	0.250	1	0.250	1	0.250	1	0.032	1	0.49	1	0.008	1	0.34	1	1.25	3	21	37
	67	1	3	1	5	0	5	0	1	1	5	0	1	0.000	5	0.000	1	0.000	1	0.000	1	0.010	1	0.70	1	0.000	1	0.50	1	1.65	5	21	37
	86	1	3	1	5	0	5	0	1	1	5	0	1	0.000	5	0.000	1	0.000	1	0.000	1	0.040	1	0.04	1	0.000	1	0.00	1	0.00	1	17	33
	73	0	1	0	1	0	1	0	1	0	1	0	1	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1	0.00	1	0.000	1	0.00	1	0.00	1	7	15
	49	0	1	0	1	0	1	0	1	0	1	0	1	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1	0.00	1	0.000	1	0.00	1	0.00	1	7	15
	66	0	1	0	1	0	1	0	1	0	1	0	1	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1	0.00	1	0.000	1	0.00	1	0.00	1	7	15
	71	0	1	0	1	0	1	0	1	0	1	0	1	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1	0.00	1	0.000	1	0.00	1	0.00	1	7	15
Upland Sites																															
	5	4	5	2	5	3	1	3	5	1	5	3	5	0.697	3	1.000	5	1.000	5	0.727	3	0.228	5	2.80	3	0.166	5	2.66	3	0.97	3	31	61
	92	1	3	1	5	1	3	1	3	0	1	1	3	0.000	5	1.000	5	1.000	5	1.000	5	0.107	3	6.15	5	0.107	3	6.15	5	1.78	5	29	59
	36	1	3	0	1	1	3	1	3	0	1	1	3	1.000	1	1.000	5	1.000	5	1.000	5	0.225	5	5.69	5	0.225	5	5.69	5	1.16	3	23	53
	37	1	3	1	5	1	3	1	3	0	1	1	3	0.000	5	1.000	5	1.000	5	1.000	5	0.100	3	1.95	3	0.100	3	1.95	3	1.06	3	27	53
	8	1	3	0	1	1	3	1	3	0	1	0	1	1.000	1	1.000	5	1.000	5	1.000	5	0.222	5	7.02	5	0.222	5	7.02	5	0.97	3	23	51
	2	1	3	0	1	1	3	1	3	0	1	1	3	1.000	1	1.000	5	1.000	5	1.000	5	0.121	3	8.54	5	0.121	5	8.54	5	1.07	3	23	51
	3	2	5	1	5	1	3	1	3	1	5	1	3	0.923	1	1.000	5	1.000	5	0.923	5	0.100	3	1.10	1	0.092	3	1.07	1	1.00	3	33	51
	93	1	3	1	5	1	3	1	3	0	1	1	3	0.000	5	1.000	5	1.000	5	1.000	5	0.018	1	0.30	1	0.018	1	0.30	1	1.18	3	27	45
	1	2	5	0	1	2	1	2	5	0	1	1	3	1.000	1	1.000	5	1.000	5	1.000	5	0.039	1	1.93	3	0.039	1	1.93	3	1.08	3	25	43
	90	1	3	0	1	1	3	1	3	0	1	0	1	1.000	1	1.000	5	1.000	5	1.000	5	0.025	1	1.16	1	0.025	1	1.16	1	1.64	5	25	37
	35	1	3	0	1	1	3	1	3	0	1	0	1	1.000	1	1.000	5	1.000	5	1.000	5	0.005	1	0.18	1	0.005	1	0.18	1	1.36	5	25	37
	79	1	3	0	1	1	3	1	3	0	1	0	1	1.000	1	1.000	5	1.000	5	1.000	5	0.007	1	0.20	1	0.007	1	0.20	1	0.76	1	21	33
Lowland mean		2.05		1.47		0.68		0.68		0.95		0.68		0.17		0.37		0.37		0.23		0.07		1.01		0.02		0.77		0.66		19.73	37.74
stderr		0.32		0.24		0.18		0.18		0.17		0.18		0.06		0.09		0.09		0.08		0.01		0.23		0.01		0.23		0.15		1.89	3.23
stddev		1.38		1.02		0.79		0.79		0.74		0.78		0.26		0.42		0.42		0.33		0.06		0.99		0.03		0.99		0.66		7.89	13.39
Upland mean		1.38		0.54		1.15		1.15		0.23		0.85		0.66		1.00		1.00		0.90		0.09		2.85		0.09		2.83		1.08		25.92	47.46
stderr		0.23		0.18		0.18		0.18		0.12		0.21		0.12		0.00		0.00		0.07		0.02		0.79		0.02		0.79		0.11		0.92	2.29
stdev		0.86		0.65		0.60		0.60		0.37		0.80		0.42		0.00		0.00		0.08		0.08		2.83		0.08		2.84		0.26		3.42	8.50
mean-90%CL		0.97		0.22		0.83		0.83		0.02		0.47		0.44		1.00		1.00		0.76		0.05		1.45		0.05		1.43		0.88			
mean+90%CL		1.80		0.85		1.48		1.48		0.44		1.23		0.89		1.00		1.00		1.03		0.13		4.26		0.12		4.24		1.28			
SCORE																															
5		>1.80		>.85		<.83		>1.48		>.44		>1.23		<.44		>.90		>.90		>.90		>.13		>4.3		>.12		>4.24		>1.28			
3		1.0-1.80		.22-.85		.83-1.48		.83-1.48		.02-.44		.47-1.23		.44-.89		.5-.9		.5-.9		.76-.90		.05-.13		1.4-4.3		.05-.12		1.43-4.24		.88-1.28			
1		<1		<.22		>1.48		<.83		<.02		<.47		>.89		<.5		<.5		<.76		<.05		<1.4		<.05		<1.43		<.88			

Table 25. Absolute values and respective scores for fish metrics for streams in the SRP ecoregion. Scores totaled based on results of PCA and all metrics combined. Note: SC equals SCORE.

STRM	SPECIES RICHNESS	SC	NATIVE RICHNESS	SC	INTRO RICHNESS	SC	SALMONID RICHNESS	SC	BENTHIC RICHNESS	SC	INTOLER RICHNESS	SC	% INTRODUCED	SC	% CARNIVORES	SC	% INVERTIVORES	SC	% SALMONIDAE	SC	DENSITY (No./m2)	SC	BIOMASS (g/m2)	SC	SALMONID DENSITY	SC	SALMONID BIOMASS	SC	CONDITION FACTOR	SC	PCA SCOR	TOTAL SCORE
Lowland Sites																																
45	2	5	1	5	1	1	1	5	1	5	0	1	0.857	3	0.857	3	0.857	3	0.857	3	0.233	5	3.04	5	0.200	5	2.96	5	0.92	3	28	57
15	2	5	1	5	1	1	1	5	1	5	1	3	0.476	5	1.000	5	1.000	5	0.476	1	0.212	5	1.03	3	0.101	5	0.66	3	0.73	1	28	57
48	4	5	3	5	1	1	1	5	1	5	0	1	0.290	5	0.290	1	0.290	1	0.290	1	3.082	5	8.63	5	0.894	5	2.67	5	1.07	3	22.	53
44	4	5	3	5	1	1	1	5	1	5	0	1	0.246	5	0.246	1	0.246	1	0.246	1	0.196	5	3.25	5	0.048	3	2.54	5	1.02	3	20	51
47	1	1	0	1	1	1	1	5	0	1	0	1	1.000	1	1.000	5	1.000	5	1.000	5	0.750	5	8.57	5	0.750	5	8.57	5	1.29	3	34	49
17	1	1	0	1	1	1	1	5	0	1	0	1	1.000	1	1.000	5	1.000	5	1.000	5	0.225	5	4.75	5	0.225	5	4.75	5	0.66	1	32	47
52	5	5	4	5	1	1	1	5	2	5	1	3	0.009	5	0.011	1	0.011	1	0.009	1	0.950	5	1.20	3	0.008	1	0.05	1	1.14	3	16	45
27	4	5	3	5	1	1	1	5	1	5	0	1	0.055	5	0.055	1	0.055	1	0.055	1	0.285	5	5.32	5	0.016	1	1.06	3	0.78	1	14	45
16	4	5	3	5	1	1	1	5	1	5	0	1	0.027	5	0.027	1	0.027	1	0.027	1	1.018	5	8.90	5	0.027	3	.0.37	1	0.86	1	14	45
32	6	5	5	5	0	5	0	1	2	5	1	3	0.017	5	0.051	1	0.051	1	0.000	1	0.264	5	7.66	5	0.000	1	0.00	1	0.00	1	10	45
53	2	5	1	5	1	1	1	5	1	5	1	3	0.429	5	1.000	5	1.000	5	0.429	1	0.035	1	0.25	1	0.015	1	0.05	1	0.61	1	22	45
72	2	5	2	5	0	5	0	1	1	5	1	3	0.000	5	0.500	3	0.500	3	0.000	1	0.003	1	0.02	1	0.000	1	0.00	1	0.00	1	14	41
46	2	5	2	5	0	5	0	1	2	5	1	3	0.000	5	0.800	3	0.800	3	0.000	1	0.030	1	0.03	1	0.000	1	0.00	1	0.00	1	14	41
26	2	5	2	5	0	5	0	1	1	5	0	1	0.000	5	0.000	1	0.000	1	0.000	1	0.192	5	0.30	1	0.000	1	0.00	1	0.00	1	8	39
29	2	5	2	5	0	5	0	1	1	5	0	1	0.000	5	0.000	1	0.000	1	0.000	1	0.118	5	0.10	1	0.000	1	0.00	1	0.00	1	8	39
51	3	5	3	5	0	5	0	1	1	5	0	1	0.000	5	0.000	1	0.000	1	0.000	1	0.098	5	0.27	1	0.000	1	0.00	1	0.00	1	8	39
70	1	1	0	1	1	1	1	5	0	1	0	1	1.000	1	1.000	5	1.000	5	1.000	5	0.007	1	0.52	1	0.007	1	0.52	3	1.32	3	28	35
63	1	1	1	5	0	5	0	1	1	5	0	1	0.000	5	0.000	1	0.000	1	0.000	1	0.005	1	0.02	1	0.000	1	0.00	1	0.00	1	8	31
Upland Sites																																
88	2	5	1	5	1	1	1	5	1	5	2	5	0.905	3	1.000	5	1.000	5	0.905	3	0.045	3	0.79	3	0.041	3	0.73	3	1.38	5	34	59
43	2	5	1	5	1	1	1	5	1	5	2	5	0.167	5	1.000	5	1.000	5	0.167	1	0.055	3	0.12	1	0.009	1	0.07	1	1.12	3	26	51
39	2	5	1	5	1	1	1	5	1	5	2	5	0.500	5	1.000	5	1.000	5	0.500	3	0.037	1	0.58	1	0.019	1	0.40	1	1.32	3	28	51
36	1	1	0	1	1	1	1	5	0	1	1	3	1.000	1	1.000	5	1.000	5	1.000	5	0.106	5	3.85	5	0.106	5	3.85	5	1.13	3	36	51
89	1	1	0	1	1	1	1	5	0	1	1	3	1.000	1	1.000	5	1.000	5	1.000	5	0.050	3	2.30	5	0.050	3	2.30	5	1.67	5	36	49
40	1	1	1	5	0	5	0	1	1	5	1	3	0.000	5	1.000	5	1.000	5	0.000	1	0.132	5	0.60	3	0.000	1	0.00	1	0.00	1	18	47
41	1	1	0	1	1	1	1	5	0	1	1	3	1.000	1	1.000	5	1.000	5	1.000	5	0.067	3	0.62	3	0.067	5	0.62	3	1.07	3	34	45
4	1	1	0	1	1	1	1	5	0	1	0	1	1.000	1	1.000	5	1.000	5	1.000	5	0.080	5	1.67	3	0.080	5	1.67	3	0.86	3	32	45
42	1	1	0	1	1	1	1	5	0	1	1	3	1.000	1	1.000	5	1.000	5	1.000	5	0.018	1	1.51	3	0.018	1	1.51	3	1.29	3	30	39
80	1	1	0	1	1	1	1	5	0	1	1	3	1.000	1	1.000	5	1.000	5	1.000	5	0.005	1	0.05	1	0.005	1	0.05	1	1.43	5	30	37
Lowland mean	2.67		2.00		0.61		0.61		1.00		0.33		0.30		0.44		0.44		0.30		0.43		2.99		0.13		1.34		0.60		18.22	44.67
stderr	0.34		0.32		0.11		0.11		0.14		0.11		0.09		0.10		0.10		0.09		0.17		0.78		0.06		0.52		0.12		2.02	1.61
stddev	1.45		1.37		0.49		0.49		0.58		0.47		0.39		0.43		0.43		0.39		0.71		3.32		0.26		2.21		0.50		8.56	6.64
Upland mean	1.30		0.40		0.90		0.90		0.40		1.20		0.76		1.00		1.00		0.76		0.06		1.23		0.04		1.14		1.13		30.40	47.4
stderr	0.15		0.16		0.09		0.09		0.16		0.19		0.12		0.00		0.00		0.12		0.01		0.35		0.01		0.37		0.14		1.65	1.92
stddev	0.46		0.49		0.30		0.30		0.49		0.60		0.37		0.00		0.00		0.37		0.04		1.10		0.03		1.16		0.43		5.20	6.05
mean-90%CL	1.03		0.12		0.73		0.73		0.12		0.85		0.54		1.00		1.00		0.54		0.04		0.59		0.02		0.46		0.88			
mean+90%CL	1.57		0.68		1.07		1.07		0.68		1.55		0.97		1.00		1.00		0.97		0.08		1.87		0.06		1.82		1.38			
SCORE																																
5	>1.57		>.68		<.73		>.90		>.68		>1.55		<.54		>.90		>.90		>.97		>.08		>1.87		>.06		>1.82		>1.38			
3	1.03-1.57		.12-.68		.73-.90		.73-.90		.12-.68		.85-1.55		.54-.97		.50-.90		.50-.90		.54-.97		.04-.08		.59-1.87		.02-.06		.46-1.82		.88-1.38			
1	<1.03		<.12		>.90		<.73		<.12		<.85		>.97		<.50		<.50		<.54		<.04		<.59		<.02		<.46		<.88			

Table 26a. Correlation matrix for fish metrics used in PCA for the NBR ecoregion.

	SPECIES RICHNESS	NATIVE RICHNESS	INTRODUCED RICHNESS	SALMONID RICHNESS	BENTHIC RICHNESS	INTOLERANT RICHNESS	% INTRODUCED	% CARNIVORES	% INVERTIVORES	% SALMONID	DENSITY (No./m2)	BIOMASS (g/m2)	SALMONID DENSITY	SALMONIDAE BIOMASS	CONDITION FACTOR
SPECIES RICHNESS															
NATIVE RICHNESS	0.65														
INTRODUCED RICHNESS	0.25	0.43													
SALMONID RICHNESS	0.50	0.10	-0.48												
BENTHIC RICHNESS	0.68	0.72	0.47	-0.10											
INTOLERANT RICHNESS	0.44	0.42	0.01	0.43	0.13										
% INTRODUCED	0.35	0.76	0.63	-0.24	0.54	0.16									
% CARNIVORES	0.08	-0.11	-0.14	0.60	-0.33	0.51	-0.30								
% INVERTIVORES	0.08	-0.11	-0.14	0.60	-0.33	0.51	-0.30	1.00							
% SALMONID	-0.08	-0.30	-0.11	0.47	-0.59	0.28	-0.43	0.80	0.80						
DENSITY	0.28	0.23	0.09	0.27	0.10	0.39	0.17	0.26	0.26	0.22					
BIOMASS	0.08	-0.04	-0.17	0.47	-0.20	0.43	-0.10	0.56	0.56	0.47	0.59				
SALMONID DENSITY	-0.04	-0.01	-0.05	0.30	-0.25	0.40	-0.13	0.48	0.48	0.57	0.76	0.73			
SALMONID BIOMASS	0.01	-0.10	-0.12	0.41	-0.29	0.37	-0.11	0.56	0.56	0.53	0.52	0.95	0.72		
CONDITION FACTOR	0.22	0.05	-0.10	0.57	-0.21	0.34	-0.14	0.61	0.61	0.62	0.09	0.43	0.32	0.46	

Table 26b. Correlation matrix for fish metrics used in PCA for the SRP ecoregion.

	SPECIES RICHNESS	NATIVE RICHNESS	INTRODUCED RICHNESS	SALMONID RICHNESS	BENTHIC RICHNESS	INTOLERANT RICHNESS	% INTRODUCED	% CARNIVORES	% INVERTIVORES	% SALMONID	DENSITY (No./m2)	BIOMASS (g/m2)	SALMONID DENSITY	SALMONID BIOMASS	CONDITION FACTOR
SPECIES RICHNESS															
NATIVE RICHNESS	0.86														
INTRODUCED RICHNESS	0.18	0.44													
SALMONID RICHNESS	-0.18	-0.44	-1.00												
BENTHIC RICHNESS	0.86	1.00	0.44	-0.44											
INTOLERANT RICHNESS	0.12	0.09	-0.14	0.14	0.09										
% INTRODUCED	0.70	0.86	0.51	-0.51	0.86	0.01									
% CARNIVORES	-0.55	-0.61	-0.46	0.46	-0.61	0.51	-0.63								
% INVERTIVORE	-0.55	-0.61	-0.46	0.46	-0.61	0.51	-0.63	1.00							
% SALMONID	-0.70	-0.86	-0.51	0.51	-0.86	-0.01	-1.00	0.63	0.63						
DENSITY	0.13	0.08	-0.05	0.05	0.08	-0.41	0.04	-0.33	-0.33	-0.04					
BIOMASS	-0.21	-0.31	-0.46	0.46	-0.31	-0.27	-0.37	-0.01	-0.01	0.37	0.56				
SALMONID DENSITY	-0.22	-0.36	-0.54	0.54	-0.36	-0.15	-0.53	0.27	0.27	0.53	0.48	0.66			
SALMONID BIOMASS	-0.41	-0.57	-0.58	0.58	-0.57	-0.29	-0.66	0.30	0.30	0.66	0.30	0.76	0.80		
CONDITION FACTOR	-0.38	-0.55	-0.62	0.62	-0.55	0.34	-0.63	0.47	0.47	0.63	-0.22	0.19	0.27	0.43	

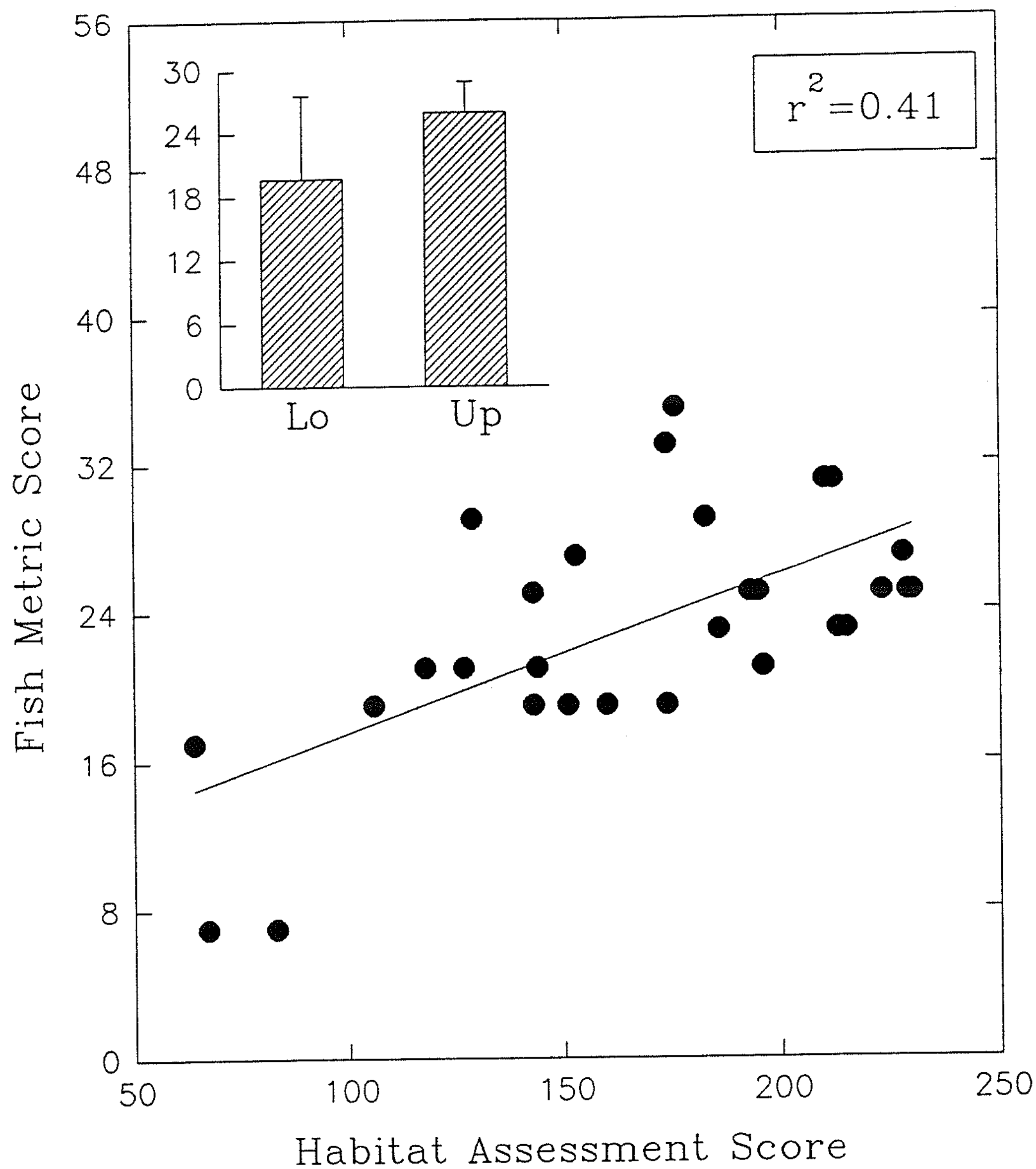

Fig. 16 Regression of the habitat assessment score against the fish metric score for streams in the NBR ecoregion. Inset reflects average metric score for lowland and upland sites; error bars equal +1 standard deviation from the mean, n=18 and 13 for lowland and upland sites, respectively.

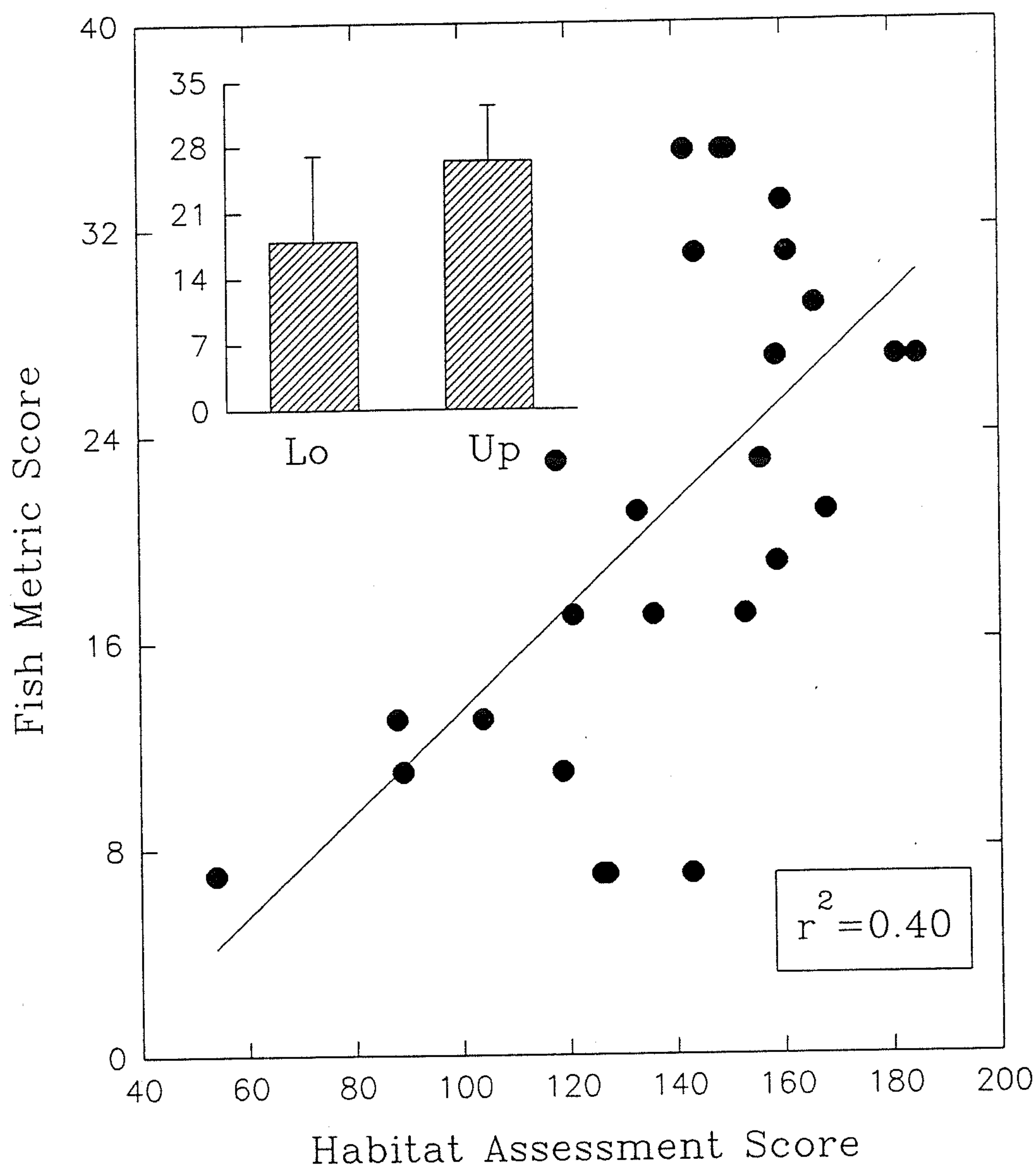

Fig. 17 Regression of the habitat assessment score against the fish metric score for streams in the SRP ecoregion. Inset reflects average metric score for lowland and upland streams; error bars equal +1 standard deviation from the mean, n=18 and 10 for lowland and upland sites, respectively.

Incorporation of the NRM Ecoregion

We examined habitat conditions and macroinvertebrate assemblages in the Northern Rocky Mountain ecoregion using data compiled from 25 streams sampled by Fisher (1989) in northern Idaho, 10 streams in the Panther Creek drainage, and five streams of the Big Creek drainage. This provided data from 35 relatively pristine streams and five degraded streams (in the Panther Creek drainage) for metric validation and development. We compared results from the NRM reference streams with habitat conditions found in respective upland sites in the NBR and SRP ecoregions.

Habitat Assessment and Evaluation

Habitat Evaluations: We recorded a number of physical and chemical measures for each site to compare with respective values found by Fisher (1989)(Table 27). For the eight variables recorded from both studies (identified with an asterisk in Table 27), none showed significant correlations. Relatively high correlations were found for specific conductance (r^2=0.36) and percent embeddedness (r^2=0.42). This suggests the importance of recording habitat measures at the time of study (e.g., discharge varies among years and seasons), techniques may vary by researcher (e.g. estimates of percent substrate embeddedness), and actual study reaches may differ. Further, a number of variables were recorded for this study, e.g. perpihyton chlorophyll a and AFDM, that were not measured by Fisher (1989).

Habitat measures recorded for the 24 reference streams displayed comparable values among drainages (Table 27). For example, streams displayed similar values for mean substrate, percent embeddedness, pH, and water depth. However, periphyton biomass showed higher values in the northern Idaho streams than in Big Creek or Panther Creek tributaries. Further, mean specific conductance and alkalinity values were lower in the Panther Creek streams than in Big Creek or northern Idaho

Table 27. Summary of habitat measures recorded for each study site. Parameters also measured by Fisher (1989) listed for comparison are labeled with an asterisk.

STATION	#	*STATION #	ELEV (m)	WIDTH/DEPTH RATIO	*W:D RATIO	WIDTH (m)	*WIDTH (m)	% COVER	*% COVER	AFDM (mg/m2)	CHL-a (mg/m2)	Q (m3/s)	TEMP (C)	SPECIFIC CONDUCTANCE (umhos)	ALKALINITY (mg/L) (CaCO3)	SUBSTRATE AVG	EMBED (%)	*EMBED (%)	SLOPE (%)	pH	MEAN DEPTH (m)	*DEPTH (m)
Study sites from Fisher (1989)																						
Little Moose	1	1	981	38	11.1	8.2	4.9	5	20	4603	16.4	0.53	5	107	59	19.6	23	22	5	8.1	0.22	0.44
Cayuse	2	3	1545	62	21.0	12.5	8.6	10	40	8376	7.6	0.24	8	25	19	17.4	8	9	1	7.7	0.20	0.41
Osier	3	4	1097	28	16.5	3.8	4.3	10	10	14873	118.2	0.11	5	110	48	19.5	40	27	2	8.3	0.13	0.28
Goose	4	5	1280	49	30.7	9.1	8.9	60	20	11401	69.6	0.35	6	114	61	33.9	21	10	2	8.4	0.19	0.29
Falls	5	29	1021	28	15.8	6.1	4.1	15	50	5313	36.2	0.15	5	74	34	38.4	17	11	2	8.0	0.22	0.26
Yellowdog	6	32	872	28	13.2	5.0	3.7	5	60	6995	28.1	0.13	7	20	17	31.4	21	25	3	7.1	0.18	0.28
Flat	7	33	914	49	24.8	6.9	5.2	25	40	5415	38.6	0.13	6	80	48	42.1	23	29	3	8.0	0.14	0.21
Cinnamon	8	34	853	23	18.4	3.9	3.5	40	70	6051	33.9	0.13	9	45	34	25.1	18	26	5	7.8	0.17	0.19
Teepee	9	35	927	20	16.8	3.5	6.4	20	10	5164	15.0	0.07	9	56	18	27.7	23	28	1	7.6	0.18	0.36
Papoose	10	52	1073	70	23.0	10.7	10.1	10	5	15669	180.9	0.50	6	147	84	20.5	35	61	4	8.3	0.15	0.44
Wendover	11	55	1000	30	15.7	3.8	3.6	85	40	9299	77.5	0.03	6	128	60	13.7	39	32	7	8.3	0.13	0.23
Doe	12	57	1049	36	15.0	5.7	4.2	40	35	4756	47.1	0.07	9	45	30	24.1	27	23	4	8.2	0.16	0.28
Post Office	13	58	914	47	16.4	9.8	6.8	75	20	3694	30.4	0.20	10	46	40	14.2	43	21	3	7.5	0.21	0.37
Shoot	14	63	1587	32	19.7	6.4	5.9	75	25	3609	6.6	0.06	6	35	38	35.2	19	25	4	7.9	0.20	0.30
Eagle	15	14	914	20	14.2	5.0	4.4	50	70	8770	40.3	0.46	7	81	48	26.0	28	14	4	NA	0.25	0.31
Quartz	16	15	927	19	16.2	7.3	7.6	50	40	3590	15.4	*0.94	9	62	44	26.9	43	26	6	NA	0.38	0.47
Gold	17	16	1109	28	22.4	8.3	6.5	25	40	6960	26.5	*0.52	13	61	36	33.3	36	20	3	NA	0.30	0.29
Red Ives	18	17	1128	24	16.9	5.5	4.9	0	10	7350	13.1	*0.94	12	78	41	20.9	39	19	2	NA	0.23	0.29
Outlaw	19	24	1128	20	12.1	3.5	4.6	100	15	10830	42.6	0.19	9	22	14	13.1	32	25	3	NA	0.17	0.38
Prospector	20	19	866	26	10.3	4.5	3.1	100	50	3100	4.96	0.20	7	29	21	17.2	39	16	3	NA	0.17	0.30
Powelson	21	126	1658	12	8.1	3.0	2.1	25	10	1260	1.8	0.15	7	25	36	1.6	70	100	2	NA	0.26	0.26
Rapid	22	127	1743	22	30.0	7.6	5.4	25	10	4190	8.39	0.48	7	31	52	30.0	42	19	1	NA	0.34	0.18
Little Goose	23	131	1664	17	16.5	3.3	2.8	25	20	7640	29.3	0.14	11	70	54	13.5	43	40	2	NA	0.19	0.17
MF Weiser	24	135	1609	17	19.1	4.9	4.4	50	30	4840	14.6	0.38	13	49	54	34.3	39	17	2	NA	0.29	0.23
Little Weiser	25	136	1372	29	30.0	9.2	5.7	75	5	8610	54.7	0.64	16	63	52	15.3	30	14	2	NA	0.32	0.19
Big Creek tributaries																						
Cave	26		1220	28		6.1		50		3980	8.6	0.31	15	39	24	18.8			6	7.9	0.15	
Pioneer	27		1165	28		3.4		75		1120	2.8	0.16	11	88	62	16.7	13		3	8.1	0.16	
Cougar	28		1095	16		3.1		75		840	1.1	0.10	12	93	36	22.6			12	7.4	0.19	
Cliff	29		1145	22		3.8		75		1810	8.8	0.18	13	73	77	22.5			11	8.2	0.17	
Rush	30		1171	57		12.0		25		6940	10.7	1.10	18	95	46	13.3	19		1	8.4	0.21	
Panther Creek tributaries																						
Big Deer	31		1550	33		6.9		75		NA	NA	0.39	12	43	14	17.1	22		3	8.1	0.21	
Fourth of July	32		1950	13		2.2		90		5371	14.0	0.05	7	54	22	14.1	27		3	7.4	0.14	
Moyer	33		2000	18		6.3		75		3726	7.1	1.02	10	38	13	23.5	18		1	7.3	0.22	
Upper Blackbird	34		2300	14		1.5		75		1040	3.0	0.03	8	58	18	11.9	44		9	7.6	0.11	
West Fork Blackbird	35		2000	20		2.7		77		4840	23.1	0.02	7	60	17	20.9	41		3	7.7	0.05	
Fisher		MEAN	1169.2	30.9	18.2	6.3	5.3	40.0	29.8	6894.3	38.3	0.21	8.3	64.1	41.6	23.8	31.7	26.4	2.9	7.9	0.2	0.3
		STD	289.2	14.1	5.9	2.5	1.9	30.0	19.3	3461.3	39.0	0.18	2.8	34.4	16.3	9.4	12.7	18.3	1.5	0.4	0.1	0.1
Big Creek		MEAN	1159.2	30		5.7		60		2938	6.4	0.37	14	78	49	18.8	16		6.6	8.0	0.18	
		STD	40.5	14		3.3		20		2284	3.7	0.37	2	21	19	3.5	3		4.3	0.3	0.02	
Panther Creek		MEAN	1960.0	20		3.9		78		2995	9.4	0.30	9	51	17	17.5	30		3.5	7.6	0.15	
		STD	239.6	7		2.2		6		2115	8.3	0.38	2	9	3	4.3	10		2.6	0.3	0.06	

streams. Panther Creek streams also were at higher elevations than Big Creek or northern Idaho streams.

Habitat evaluations were recorded for the 24 streams with most sites, as expected, displaying high habitat quality (Table 28). Red Ives Creek had the lowest habitat value at 110, with most sites displaying values greater than 150 and a number of sites having values in excess of 170 out of a possible 180. Most streams had values within 80% of the possible maximum value, with Panther Creek sites displaying the highest mean score and northern Idaho streams the lowest mean score (149)(Fig. 18). The Big Creek sites showed the lowest scores for stream embeddedness reflecting the higher input of fine sediment from granitic bedrock and soils. Northern Idaho streams displayed the lowest values for percent cover and stream cover.

Macroinvertebrate Evaluation: Four streams in northern Idaho (Powelson, Gold, Papoose, and Flat Creeks) were sampled for macroinvertebrates and the results compared with data from Fisher (1989). Although some discrepancy existed in identification of taxa, e.g. Fisher consistently had higher species richness and EPT richness values, most other biotic metrics appeared robust enough to ameliorate the differences (Table 29). For example, highly similar values were found for %EPT and %CH+O. Based on these results, we felt confident that metrics could be calculated for all 25 streams using Fisher' data set and compared with metrics from the Big Creek tributaries and Panther Creek tributaries.

Biotic metrics were generated from Fisher's (1989) raw data set (Table 30) with the top 20 most abundant taxa also listed. To eliminate the discrepancies in richness values some obvious "split" taxonomic groups, e.g. *Baetis* species, were combined. Richness values ranged from 17 to 33, and %EPT from 38 to 92%. Further, percent miners ranged from 0 to 46%; indeed a number of sites had no Chironomidae recorded.

PCA was used to determine any major differences among the 25 study streams from Fisher using metrics (Fig. 19) and the 20 most abundant taxa (Fig. 20). It is important to remember that only

Riffle/Run Streams	#	SUBSTRATE COVER	EMBEDDEDNESS	FLOW VELOCITY	CANOPY COVER	CHANNEL ALTERATION	BOTTOM SCOURING	POOL/ RIFFLE	WIDTH/ DEPTH	BANK STABILITY	BANK VEGETATION	STREAM COVER	RIPARIAN WIDTH	TOTAL SCORE	% MAXIMUM
Little Moose	1	20	19	18	18	19	14	13	15	10	10	10	9	175	97.2
Cayuse	2	15	20	8	13	5	4	10	9	7	10	7	10	118	65.6
Osier	3	17	17	15	18	15	15	10	15	10	10	9	8	159	88.3
Goose	4	19	20	18	19	15	15	14	15	10	10	9	8	172	95.6
Falls	5	20	20	18	20	15	15	14	15	10	10	9	9	175	97.2
Yellowdog	6	18	20	19	16	11	14	10	15	8	7	7	7	152	84.4
Flat	7	20	20	16	20	15	15	13	15	10	10	9	10	173	96.1
Cinnamon	8	20	20	18	20	15	15	12	15	10	10	8	10	173	96.1
Teepee	9	16	20	10	12	11	13	10	15	7	10	5	10	139	77.2
Papoose	10	17	18	13	15	10	15	9	15	10	10	6	8	146	81.1
Wendover	11	16	16	12	18	14	15	11	14	10	9	7	8	150	83.3
Doe	12	19	17	13	16	12	14	10	15	9	10	8	7	150	83.3
Post Office	13	17	14	17	16	12	11	12	15	10	10	8	10	152	84.4
Shoot	14	20	20	15	20	15	15	13	15	10	10	9	8	170	94.4
Eagle	15	16	18	13	17	9	13	9	10	7	7	8	7	134	74.4
Quartz	16	15	17	12	18	11	11	10	9	7	7	8	5	130	72.2
Gold	17	19	18	17	12	15	12	11	10	10	8	9	8	149	82.8
Red Ives	18	11	12	10	13	8	9	6	7	8	10	10	6	110	61.1
Outlaw	19	18	17	15	10	12	10	11	11	10	10	9	8	141	78.3
Prospector	20	16	17	17	16	14	12	12	13	8	8	9	8	150	83.3
Powelson	21	18	18	18	12	10	7	15	11	10	10	5	10	144	80.0
Rapid	22	13	10	18	17	9	8	12	12	7	7	8	9	130	72.2
Little Goose	23	15	15	10	12	12	12	15	11	9	10	5	9	135	75.0
Middle Weiser	24	16	17	17	16	14	13	13	13	10	8	6	10	153	85.0
Little Weiser	25	17	11	14	18	10	8	14	15	7	8	10	9	141	78.3
Big Creek tributaries															
Cave	26	20	8	17	17	15	11	13	15	10	10	10	8	154	83.2
Pioneer	27	19	15	13	18	15	15	14	15	10	9	10	8	161	87.0
Cougar	28	18	15	16	17	13	7	10	13	9	9	8	5	140	75.7
Cliff	29	20	16	15	20	13	11	14	15	10	9	10	9	162	87.6
Rush	30	20	19	15	17	15	15	11	15	10	10	10	8	165	89.2
Panther Creek tributaries															
Big Deer	31	20	20	17	19	13	14	14	14	10	9	9	9	168	90.8
Fourth of July	32	20	20	20	20	15	15	15	14	10	10	10	7	176	95.1
Moyer	33	18	20	10	17	13	15	8	13	10	9	9	8	150	81.1
Upper Blackbird	34	19	16	15	20	15	14	14	15	10	10	9	9	166	89.7
WF Blackbird	35	20	20	15	19	15	14	12	15	10	10	10	8	168	90.8
Fisher	MEAN	17.1	17.2	14.8	16.1	12.3	12.2	11.6	13.0	9.0	9.2	7.9	8.4	148.8	82.7
	STD	2.3	2.8	3.1	2.9	3.0	3.0	2.1	2.5	1.3	1.2	1.5	1.3	17.3	9.6
Big	MEAN	19.4	14.6	15.2	17.8	14.2	11.8	12.4	14.6	9.8	9.4	9.6	7.6	156.4	84.5
	STD	0.8	3.6	1.3	1.2	1.0	3.0	1.6	0.8	0.4	0.5	0.8	1.4	9.0	4.8
Panther	MEAN	19.4	19.2	15.4	19.0	14.2	14.4	12.6	14.2	10.0	9.6	9.4	8.2	165.6	89.5
	STD	0.8	1.6	3.3	1.1	1.0	0.5	2.5	0.7	0.0	0.5	0.5	0.7	8.5	4.6

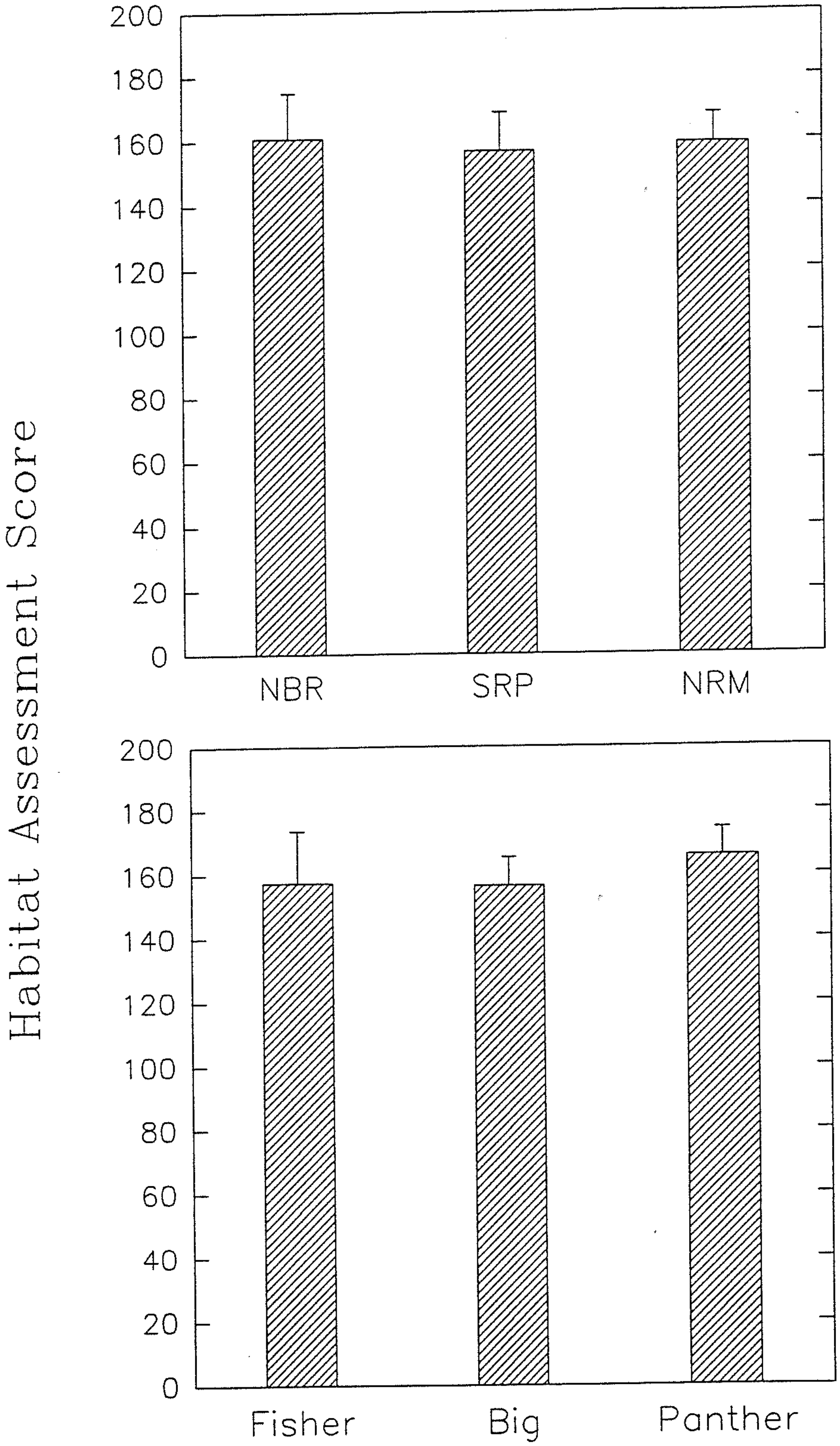

Fig. 18. Habitat assessment scores for reference streams in each ecoregion and for different catchments of the NRM ecoregion. Error bars equal +1 standard deviation from the mean.

Table 29. Comparison of macroinvertebrate data collected by ISU and Fisher from the same streams.

TAXA	Powelson		Gold		Papoose		Flat	
	ISU	Fisher	ISU	Fisher	ISU	Fisher	ISU	Fisher
Density	197	318	256	575	1012	358	2824	810
Richness	17	28	25	33	21	34	28	32
EPT Richness	11	18	16	23	9	23	19	22
% EPT	0.45	0.55	0.41	0.52	0.36	0.46	0.64	0.52
EPT/C	5.18	3.16	2.26	1.60	2.56	2.51	3.34	1.54
EPT/C+O	1.42	2.07	1.26	1.59	1.06	1.65	2.25	1.52
H'	1.01	1.17	1.15	0.99	1.07	1.16	1.14	1.06
Simpson's	0.13	0.09	0.09	0.17	0.12	0.11	0.10	0.16
% Dominance	0.23	0.17	0.18	0.33	0.20	0.22	0.19	0.33
% Scrapers	0.19	0.03	0.22	0.18	0.21	0.23	0.32	0.18
% Filterers	0.00	0.14	0.09	0.00	0.03	0.02	0.02	0.01
% Shredders	0.16	0.21	0.05	0.02	0.00	0.01	0.04	0.03
% Chironomidae	0.09	0.17	0.18	0.33	0.14	0.18	0.19	0.33
% C+O	0.31	0.26	0.33	0.33	0.34	0.28	0.29	0.34

Table 30. List of top 20 most abundant macroinvertebrate taxa and summarized metrics for selected study streams of Fisher (1989).

Variable	Station: 1	3	4	5	29	32	33	34	36	52	55	57	58
Chironomidae	132	33	52	132	9	192	271	255	26	65	15	35	12
Baetis	90	5	89	53	71	92	61	35	9	31	108	82	35
Heterlimnius	95	3	51	60	30	14	89	24	48	78	79	18	51
Sweltsa	1	22	15	50	27	83	125	81	106	23	1	6	1
Cinygmula	4	28	8	86	59	3	8			29	74	49	27
Serratella tibialis	114	7	12	40	4	78	21	22	4	3	52	42	7
Rhyacophila	21	15	22	25	17	8	35	41	8	17	20	17	7
Drunella coloradensis	20	3	43	7	25	4	6	8	12	6	113	65	30
Megarcys	9		5		23	13	37	19	2	1	27	26	7
Epeorus deceptivus				30	55	9	26	5	1			1	
Rithrogena		31		15	23	50	21	6	16				
Zapada		33	7	14	20	1	19	12	1		1	1	
Oligochaeta			4	12			4	30	6	34	25		
Skwala		10				24	24	7	39				
Brachycentrus	11	2	82	4	1	3	3	1		5		4	
Arctopsyche	2		2	1	2	31		10	9		1	1	
Dolophilodes	7		30					4					
Epeorus longimanus	3	3	2	21	1			12		12	4	25	3
Drunella doddsi		2	1	1	8	17	15	1	7	2	14	7	10
Simulium	1	4		6		5	2	5		2	4	7	1
Total Numbers	554	241	502	637	443	708	812	616	333	358	589	435	242
Species Richness	30	25	27	32	22	29	32	33	29	32	27	33	26
EPT/Chironomidae	1.58	5.64	6.35	2.34	42.56	2.28	1.56	1.11	5.85	2.51	22.07	10.40	10.58
% Dominance	0.24	0.14	0.18	0.21	0.16	0.27	0.33	0.41	0.32	0.22	0.19	0.19	0.21
EPT Richness	18	18	19	22	18	21	21	25	20	21	19	25	19
% Shredders	0.02	0.14	0.02	0.07	0.16	0.00	0.04	0.04	0.02	0.00	0.01	0.01	0.01
% Scrapers	0.21	0.41	0.30	0.35	0.55	0.27	0.18	0.13	0.14	0.25	0.54	0.56	0.48
% Filters	0.03	0.02	0.17	0.02	0.01	0.06	0.01	0.03	0.03	0.02	0.01	0.03	0.00
% EPT	0.38	0.77	0.66	0.49	0.86	0.62	0.52	0.46	0.46	0.46	0.56	0.84	0.52
H' Diversity	0.96	1.13	1.11	1.17	1.12	1.07	1.03	1.00	1.04	1.13	1.06	1.15	1.14
HBI	3.61	2.04	2.61	3.10	2.16	2.94	3.20	3.54	1.80	3.53	2.95	2.64	2.88
% Predators	0.06	0.16	0.17	0.14	0.12	0.19	0.25	0.18	0.47	0.16	0.10	0.13	0.13
% Miners	0.24	0.14	0.11	0.23	0.02	0.27	0.34	0.46	0.10	0.28	0.07	0.08	0.05
% Gatherers	0.44	0.12	0.23	0.20	0.13	0.21	0.18	0.16	0.24	0.29	0.27	0.19	0.32
Simpsons	0.16	0.10	0.10	0.10	0.09	0.13	0.16	0.20	0.15	0.11	0.12	0.10	0.10
EPT/C+O	1.58	5.64	5.89	2.15	42.56	2.28	1.54	1.00	4.75	1.65	8.28	10.40	10.58

Note. Station numbers after Fisher (1989).

Table 30. (cont.)

Variable	Station: 63	14	15	16	17	24	19	126	127	131	135	136
Chironomidae	40							55	3	9	22	6
Baetis	23	6	97	65	20	8	27	6	2	17	30	23
Heterlimnius	8	22	55	76	15	36	8	2	15	9	1	44
Sweltsa	6	32	33	106	32	17	16	13	5	3	4	6
Cinygmula	36	50	6	19	11	13	13	2	13	10	34	
Serratella tibialis		3	22	38	6	6	2	8	28	9	7	5
Rhyacophila	8	4	19	25	8	8		20	7	8	18	8
Drunella coloradensis	2	1	9		1	10			4	2	5	
Megarcys		5	14	5	5	5	4	4	18		25	1
Epeorus deceptivus	1	12	5	6	28	3	1		2		11	15
Rithrogena				2	21	2		1	3		3	8
Zapada	8	2	21	2	10	4	5	27	2	2	1	
Oligochaeta	1		4	1				29		1	8	
Skwala	7	3	6	10	1	2		19	5			
Brachycentrus			4		8		1		1			
Arctopsyche			16		3	3			4		5	35
Dolophilodes			30		1			1	8	4	14	3
Epeorus longimanus			5	5	2		1		2			
Drunella doddsi			2	2	3		1		1	1		
Simulium	2							45	9			1
Total Numbers	176	192	396	382	199	133	102	318	149	95	202	181
Species Richness	24	20	27	26	23	17	21	28	27	20	21	22
EPT/Chironomidae	2.70							3.16	39.33	8.22	7.68	20.17
% Dominance	0.23	0.26	0.24	0.28	0.16	0.27	0.26	0.17	0.19	0.18	0.17	0.24
EPT Richness	16	19	24	20	22	16	19	18	21	15	16	15
% Shredders	0.06	0.13	0.11	0.03	0.11	0.07	0.13	0.21	0.03	0.12	0.01	0.04
% Scrapers	0.39	0.41	0.32	0.26	0.44	0.30	0.46	0.03	0.24	0.33	0.41	0.27
% Filters	0.01	0.00	0.05	0.00	0.06	0.02	0.01	0.14	0.09	0.00	0.02	0.20
% EPT	0.61	0.89	0.84	0.79	0.92	0.73	0.91	0.55	0.79	0.78	0.84	0.67
H' Diversity	1.09	1.07	1.16	0.95	1.16	1.07	1.07	1.17	1.21	1.13	1.10	1.06
HBI	4.00	1.90	2.36	2.02	1.41	2.02	2.63	3.21	1.66	2.71	2.58	2.48
% Predators	0.18	0.22	0.15	0.33	0.25	0.20	0.23	0.14	0.22	0.07	0.20	0.08
% Miners	0.23	0.00	0.01	0.00	0.00	0.00	0.00	0.26	0.02	0.11	0.15	0.03
% Gatherers	0.12	0.24	0.36	0.37	0.15	0.41	0.18	0.21	0.40	0.38	0.20	0.38
Simpsons	0.12	0.13	0.11	0.16	0.09	0.12	0.13	0.09	0.09	0.09	0.10	0.13
EPT/C+O	2.63		83.25	300.00				2.07	39.33	7.40	5.63	20.17

Note. Station numbers after Fisher (1989).

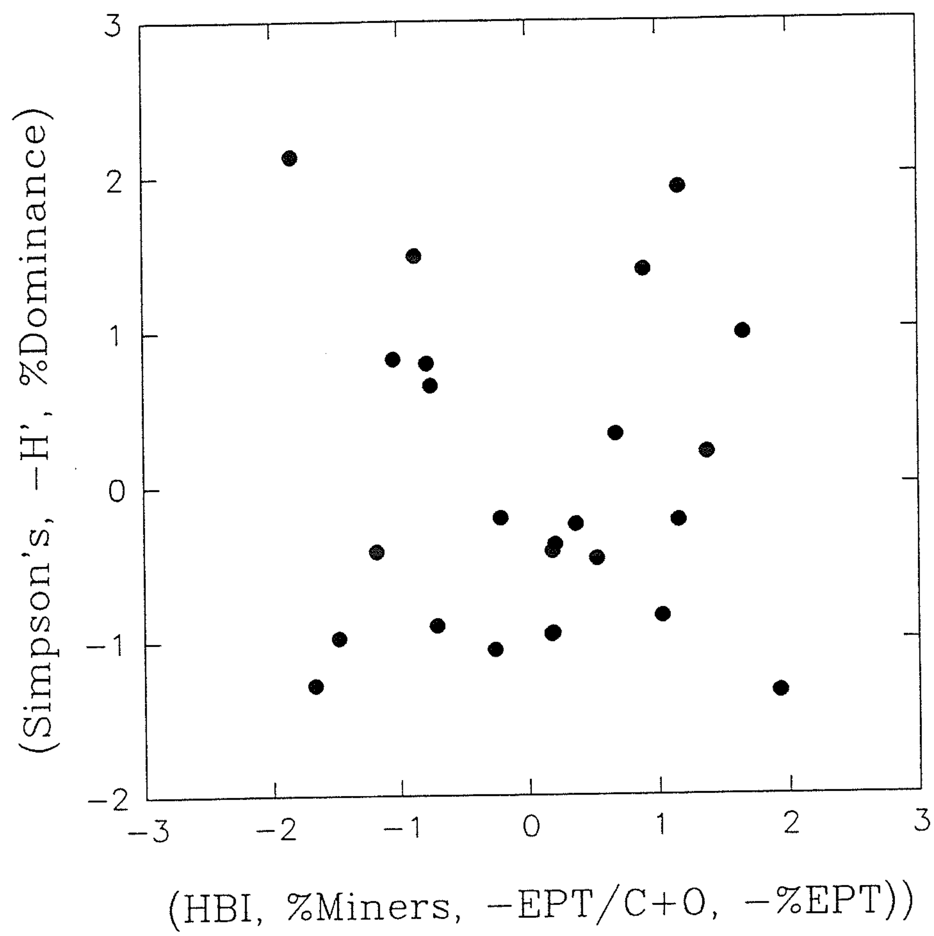

Fig. 19. PCA scatterplot for the 25 study sites of Fisher (1989) based on macroinvertebrate metrics. Signs in front of each metric indicate relationship with its particular axis.

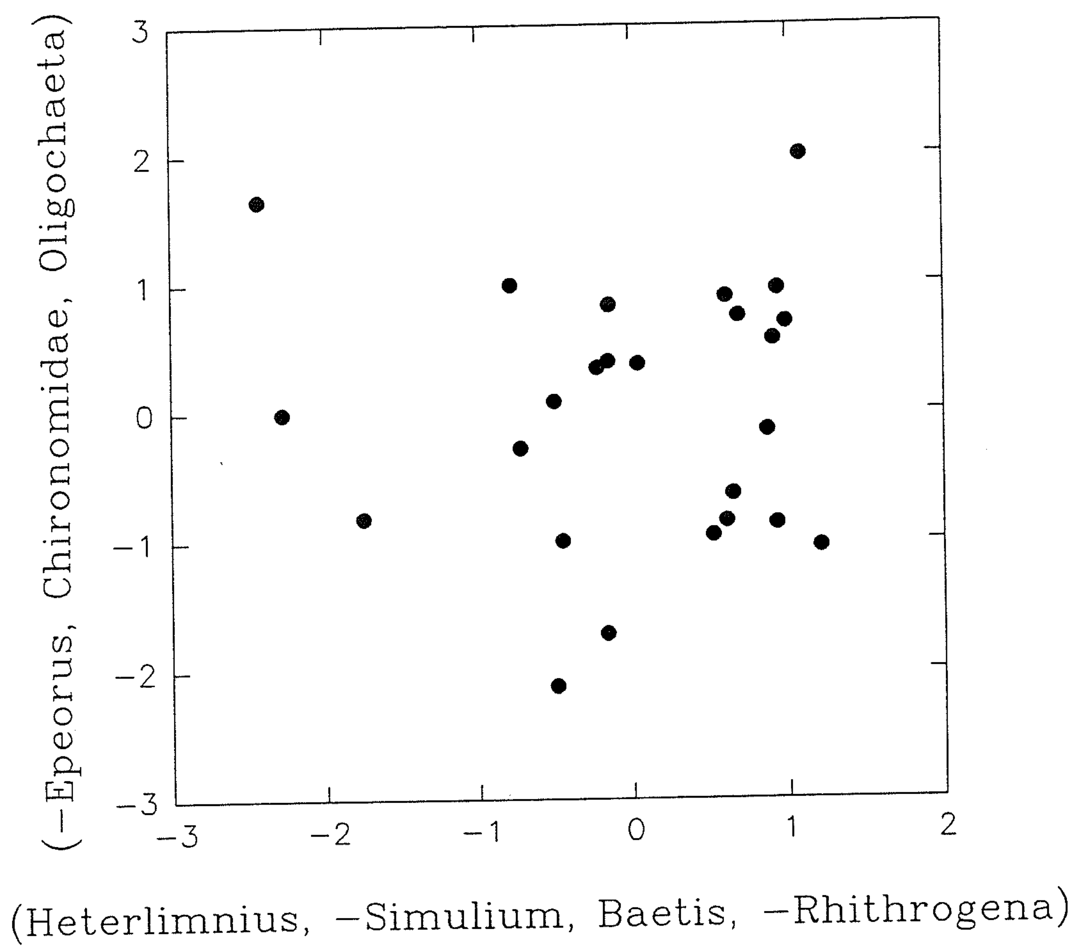

Fig. 20. PCA scatterplot for the 25 study sites of Fisher (1989) based on the top 20 most abundant macroinvertebrate taxa. Signs in front of taxa along each axis indicate relationship with that axis.

the more pristine sites were analyzed; i.e. relatively good habitat scores were generated for all sites. No clear pattern emerged from the PCA results. However, there also was no clear grouping among the 25 sites based on metric data. Three sites showed separation from the others based on taxonomic differences; having low numbers of *Heterlimnius* and *Baetis*, and high values for *Simulium*, chironomids, and oligochaetes. These data suggest a wide range in biotic conditions, perhaps due to life history differences, even among these relatively pristine streams and the PCA would be an effective means for selecting "reference" sites for future monitoring of degraded stream systems. For example, the three streams that were separated from the others may be outliers because they were sampled at a different time (season) than the other study sites.

The mean absolute values for a number of macroinvertebrate metrics differed among drainage basins in the NRM ecoregion (Table 31). For example, species richness and the related EPT richness were lowest in the Panther Creek drainage, %Scrapers and %EPT were greatest in northern Idaho streams, while %Miners were lowest in the northern Idaho streams. HBI was highest (6.40) in the Panther Creek sites, while total numbers were lowest for northern Idaho streams. However, Shannon's H' diversity and Simpson's values were similar among basins.

PCA was used to delineate differences in metrics among streams from the three study areas (Fig. 21). The Panther Creek sites were clearly separate from the Big Creek and northern Idaho streams. Further, Big Creek sites were displaced to the left of the northern Idaho streams suggesting possible basin level differences in assemblage structure. Metrics found important for delineating study areas based on the PCA results included total numbers, species richness, EPT/C, EPT richness, % scrapers, %EPT, HBI, and % miners. Metric scores were derived from values obtained from the northern Idaho streams (Table 32). Panther Creek streams displayed the lowest mean metric score (8.8), Big Creek streams were intermediate (14), and northern Idaho highest (24.6). These data indicate that biotic differences exist among drainages within the same ecoregion. Since these differences

Table 31. Macroinvertebrate metrics for study streams in the [illegible]

Station		Total Numbers	Species Richness	EPT/C	% Dominance	EPT Richness	% Shredders	% Scrapers	% Filterers	%EPT	H'	HBI	% Predators	% Miners	% Gatherers	Simpson's
Little Moose		554	30	1.58	0.24	18	0.02	0.21	0.03	0.38	0.96	3.61	0.06	0.24	0.44	0.16
Cayuse		241	25	5.64	0.14	18	0.14	0.41	0.02	0.77	1.13	2.04	0.16	0.14	0.12	0.10
Osier		502	27	6.35	0.18	19	0.02	0.30	0.17	0.66	1.11	2.61	0.17	0.11	0.23	0.10
Goose		637	32	2.34	0.21	22	0.07	0.35	0.02	0.49	1.17	3.10	0.14	0.23	0.20	0.10
Falls		443	22	42.56	0.16	18	0.16	0.55	0.01	0.86	1.12	2.16	0.12	0.02	0.13	0.09
Yellowdog		708	29	2.28	0.27	21	0.00	0.27	0.06	0.62	1.07	2.94	0.19	0.27	0.21	0.13
Flat		812	32	1.56	0.33	21	0.04	0.18	0.01	0.52	1.03	3.20	0.25	0.34	0.18	0.16
Cinnamon		616	33	1.11	0.41	25	0.04	0.13	0.03	0.46	1.00	3.54	0.18	0.46	0.16	0.20
Teepee		333	29	5.85	0.32	20	0.02	0.14	0.03	0.46	1.04	1.80	0.47	0.10	0.24	0.15
Papoose		358	32	2.51	0.22	21	0.00	0.25	0.02	0.46	1.13	3.53	0.16	0.28	0.29	0.11
Wendover		589	27	22.07	0.19	19	0.01	0.54	0.01	0.56	1.06	2.95	0.10	0.07	0.27	0.12
Doe		435	33	10.40	0.19	25	0.01	0.56	0.03	0.84	1.15	2.64	0.13	0.08	0.19	0.10
Post Office		242	26	10.58	0.21	19	0.01	0.48	0.00	0.52	1.14	2.88	0.13	0.05	0.32	0.10
Shoot		176	24	2.70	0.23	16	0.06	0.39	0.01	0.61	1.09	4.00	0.18	0.23	0.12	0.12
Eagle		192	20	4.79	0.26	19	0.13	0.41	0.00	0.89	1.07	1.90	0.22	0.00	0.24	0.13
Quartz		396	27	4.79	0.24	24	0.11	0.32	0.05	0.84	1.16	2.36	0.15	0.01	0.36	0.11
Gold		382	26	4.79	0.28	20	0.03	0.26	0.00	0.79	0.95	2.02	0.33	0.00	0.37	0.16
Red Ives		199	23	4.79	0.16	22	0.11	0.44	0.06	0.92	1.16	1.41	0.25	0.00	0.15	0.09
Outlaw		133	17	4.79	0.27	16	0.07	0.30	0.02	0.73	1.07	2.02	0.20	0.00	0.41	0.12
Prospector		102	21	4.79	0.26	19	0.13	0.46	0.01	0.91	1.07	2.63	0.23	0.00	0.18	0.13
Powelson		318	28	3.16	0.17	18	0.21	0.03	0.14	0.55	1.17	3.21	0.14	0.26	0.21	0.09
Rapid		149	27	39.33	0.19	21	0.03	0.24	0.09	0.79	1.21	1.66	0.22	0.02	0.40	0.09
Little Goose		95	20	8.22	0.18	15	0.12	0.33	0.00	0.78	1.13	2.71	0.07	0.11	0.38	0.09
MF Weiser		202	21	7.68	0.17	16	0.01	0.41	0.02	0.84	1.10	2.58	0.20	0.15	0.20	0.10
Little Weiser		181	22	20.17	0.24	15	0.04	0.27	0.20	0.67	1.06	2.48	0.08	0.03	0.38	0.13
Big Creek tributaries																
Cave		9973	31	1.21	0.22	17	0.01	0.09	0.09	0.21	1.07	4.58	0.19	0.39	0.23	0.14
Pioneer		19625	34	12.95	0.40	18	0.09	0.27	0.08	0.41	0.95	4.53	0.08	0.44	0.04	0.22
Cougar		6593	30	7.76	0.41	16	0.10	0.16	0.03	0.34	1.07	4.14	0.07	0.46	0.18	0.20
Cliff		6081	22	15.87	0.42	14	0.06	0.26	0.04	0.42	1.00	3.90	0.05	0.45	0.14	0.21
Rush		12963	35	0.57	0.49	20	0.02	0.08	0.06	0.28	0.97	4.60	0.16	0.52	0.17	0.26
Panther Creek tributaries																
Big Deer		10793	19	4.34	0.11	11	0.09	0.28	0.13	0.41	1.09	4.27	0.11	0.20	0.20	0.10
Fourth of July		6603	18	2.66	0.20	13	0.10	0.15	0.00	0.42	1.08	5.77	0.24	0.36	0.15	0.11
Moyer		6374	16	0.61	0.53	10	0.01	0.05	0.02	0.13	0.69	8.61	0.12	0.75	0.06	0.34
Upper Blackbird		2311	18	1.10	0.35	12	0.06	0.03	0.00	0.29	0.87	7.38	0.27	0.62	0.02	0.21
WF Blackbird		3873	16	2.13	0.21	10	0.12	0.28	0.01	0.44	0.81	5.97	0.37	0.22	0.01	0.21
Fisher	mean	360	26	10.32	0.23	19	0.06	0.33	0.04	0.68	1.09	2.64	0.18	0.13	0.26	0.12
	std	200	4	11.97	0.06	3	0.06	0.13	0.05	0.16	0.06	0.65	0.08	0.13	0.10	0.03
Big	mean	11047	30	7.67	0.39	17	0.06	0.17	0.06	0.33	1.01	4.35	0.11	0.45	0.15	0.21
	std	4958	5	6.12	0.09	2	0.04	0.08	0.02	0.08	0.05	0.28	0.05	0.04	0.06	0.04
Panther	mean	5991	17	2.17	0.28	11	0.07	0.16	0.03	0.34	0.91	6.40	0.22	0.43	0.09	0.19
	std	2885	1	1.31	0.15	1	0.04	0.11	0.05	0.11	0.15	1.48	0.10	0.22	0.08	0.09

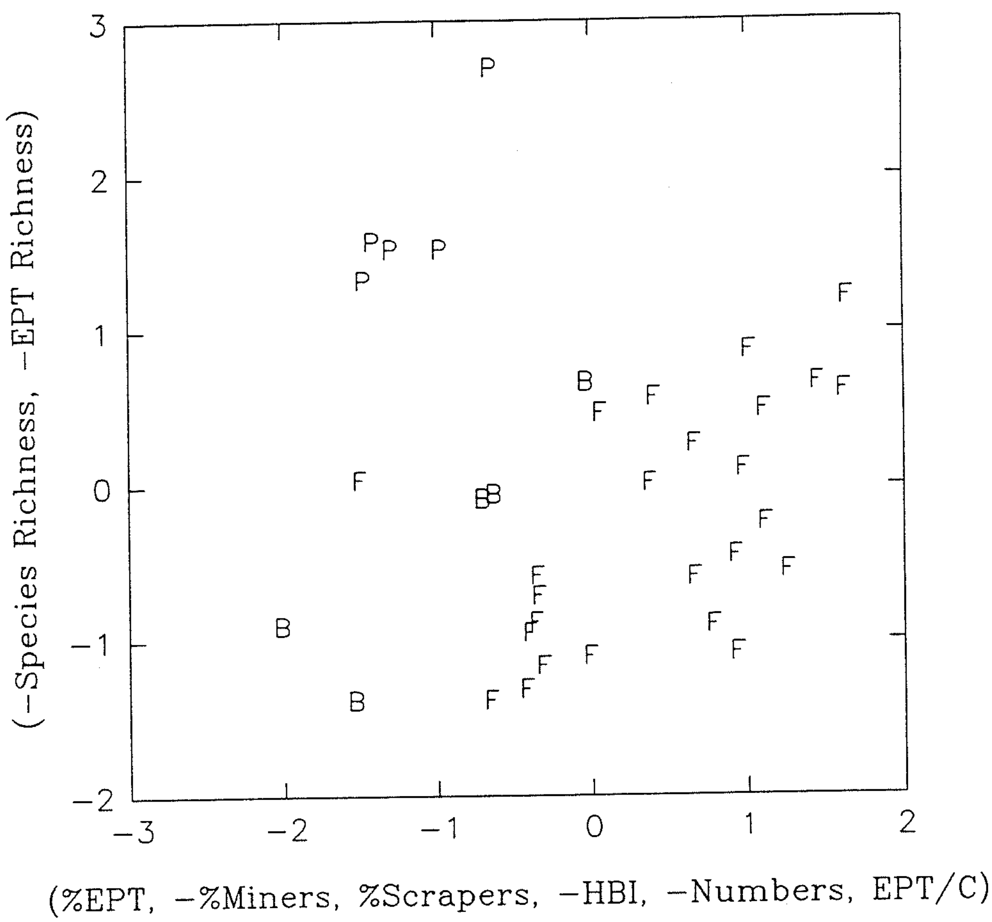

Fig. 21. PCA scatterplot using data sets from Fisher (F), Big Creek drainage (B), and the Panther Creek drainage (P) based on macroinvertebrate metrics. Signs indicate relationship of each metric to a particular axis.

Table 32. Macroinvertebrate metrics for NRM streams with respective scores for important metrics based on PCA results.

Station	Total Numbers	SCORE	Species Richness	SCORE	EPT/C	SCORE	EPT Richness	SCORE	% Scrapers	SCORE	%EPT	SCORE	HBI	SCORE	% Miners	SCORE	TOTAL SCORE
Little Moose	554	1	30	5	1.58	1	18	3	0.21	1	0.38	1	3.61	1	0.24	1	14
Cayuse	241	5	25	3	5.64	1	18	3	0.41	5	0.77	5	2.04	5	0.14	3	30
Osier	502	1	27	5	6.35	3	19	3	0.30	3	0.66	3	2.61	3	0.11	3	24
Goose	637	1	32	5	2.34	1	22	5	0.35	3	0.49	1	3.10	1	0.23	1	18
Falls	443	1	22	1	42.56	5	18	3	0.55	5	0.86	5	2.16	5	0.02	5	30
Yellowdog	708	1	29	5	2.28	1	21	5	0.27	1	0.62	3	2.94	1	0.27	1	18
Flat	812	1	32	5	1.56	1	21	5	0.18	1	0.52	1	3.20	1	0.34	1	16
Cinnamon	616	1	33	5	1.11	1	25	5	0.13	1	0.46	1	3.54	1	0.46	1	16
Teepee	333	3	29	5	5.85	1	20	5	0.14	1	0.46	1	1.80	5	0.10	3	24
Papoose	358	3	32	5	2.51	1	21	5	0.25	1	0.46	1	3.53	1	0.28	1	18
Wendover	589	1	27	5	22.07	5	19	3	0.54	5	0.56	1	2.95	1	0.07	5	26
Doe	435	1	33	5	10.40	3	25	5	0.56	5	0.84	5	2.64	3	0.08	5	32
Post Office	242	5	26	3	10.58	3	19	3	0.48	5	0.52	1	2.88	3	0.05	5	28
Shoot	176	5	24	3	2.70	1	16	1	0.39	5	0.61	1	4.00	1	0.23	1	18
Eagle	192	5	20	1	4.79	1	19	3	0.41	5	0.89	5	1.90	5	0.00	5	30
Quartz	396	3	27	5	4.79	1	24	5	0.32	3	0.84	5	2.36	5	0.01	5	32
Gold	382	3	26	3	4.79	1	20	5	0.26	1	0.79	5	2.02	5	0.00	5	28
Red Ives	199	5	23	1	4.79	1	22	5	0.44	5	0.92	5	1.41	5	0.00	5	32
Outlaw	133	5	17	1	4.79	1	16	1	0.30	3	0.73	5	2.02	5	0.00	5	26
Prospector	102	5	21	1	4.79	1	19	3	0.46	5	0.91	5	2.63	3	0.00	5	28
Powelson	318	3	28	5	3.16	1	18	3	0.03	1	0.55	1	3.21	1	0.26	1	16
Rapid	149	5	27	5	39.33	5	21	5	0.24	3	0.79	5	1.66	5	0.02	5	38
Little Goose	95	5	20	1	8.22	3	15	1	0.33	3	0.78	5	2.71	3	0.11	3	24
MF Weiser	202	5	21	1	7.68	3	16	1	0.41	5	0.84	5	2.58	3	0.15	3	26
Little Weiser	181	5	22	1	20.17	5	15	1	0.27	1	0.67	3	2.48	3	0.03	5	24
Big Creek tributaries																	
Cave	9973	1	31	5	1.21	1	17	1	0.09	1	0.21	1	4.58	1	0.39	1	12
Pioneer	19625	1	34	5	12.95	3	18	3	0.27	1	0.41	1	4.53	1	0.44	1	16
Cougar	6593	1	30	5	7.76	3	16	1	0.16	1	0.34	1	4.14	1	0.46	1	14
Cliff	6081	1	22	1	15.87	5	14	1	0.26	1	0.42	1	3.90	1	0.45	1	12
Rush	12963	1	35	5	0.57	1	20	5	0.08	1	0.28	1	4.60	1	0.52	1	16
Panther Creek tributaries																	
Big Deer	10793	1	19	1	4.34	1	11	1	0.28	3	0.41	1	4.27	1	0.20	1	10
Fourth of July	6603	1	18	1	2.66	1	13	1	0.15	1	0.42	1	5.77	1	0.36	1	8
Moyer	6374	1	16	1	0.61	1	10	1	0.05	1	0.13	1	8.61	1	0.75	1	8
Upper Blackbird	2311	1	18	1	1.10	1	12	1	0.03	1	0.29	1	7.38	1	0.62	1	8
WF Blackbird	3873	1	16	1	2.13	1	10	1	0.28	3	0.44	1	5.97	1	0.22	1	10
Fisher mean	360		26		10.32		19		0.33		0.68		2.64		0.13		24.64
std	200		4		11.97		3		0.13		0.16		0.65		0.13		6.27
Big mean	11047		30		7.67		17		0.17		0.33		4.35		0.45		14.00
std	4958		5		6.12		2		0.08		0.08		0.28		0.04		1.79
Panther mean	5991		17		2.17		11		0.16		0.34		6.40		0.43		8.80
std	2885		1		1.31		1		0.11		0.11		1.48		0.22		0.98
STDERR	40		1		2.39		0.6		0.03		0.03		0.13		0.03		
+CL(90%)	428		28		14.39		20.4		0.38		0.73		2.86		0.17		
-CL(90%)	292		25		6.25		18.5		0.28		0.62		2.42		0.09		
SCORE 5	<290		>27		>14		>20		>.37		>.73		<2.4		<.08		
3	290-430		24-27		6-14		18-20		.28-.37		.62-.73		2.4-2.9		.08-.17		
1	>430		<24		<6		<18		<.28		<.62		>2.9		>.17		

appear to reflect differences in latitude, they suggest that climate, rather than geology or a more site-specific factor, is responsible.

NRM Metric Validation

Habitat Assessment: Panther Creek tributaries were used to examine the validity of developed metrics for the NRM. In general, mining impacted streams showed lower assessment scores for channel condition, flow types, bottom scouring, pool/riffle ratios, and bank stability than reference sites, suggesting a high degree of channelization (Table 33). The amount of channel alteration also was evident in that mining streams had lower percentages of canopy coverage resulting from reductions in riparian vegetation from dredging operations. Two mining-influenced streams (Blackbird and SF Big Deer Creeks) had substantially greater values of specific conductance suggesting much greater sulfate levels (ca. 4-12X higher) and overall chemical impacts than the dredged (physically altered) and reference streams (Table 34). Water pH and alkalinity were considerably lower in Blackbird Creek than in other streams.

Principal components analysis clearly separated mining streams from reference streams based on measured physical and chemical variables with the first two axes explaining 85% of the variation (Fig. 22). Reference sites showed greater values of % canopy cover, pool/riffle ratios, bank (riparian) vegetation, and channel sinuosity than mining-impacted streams. The PCA results also indicated that measures of bank-full width, water depth, absolute measure of % canopy cover, periphyton chlorophyll a, alkalinity, and pH were important for separating stream types. These variables were incorporated into an overall habitat assessment score (Table 35). Mining-impacted streams displayed a significantly lower mean habitat score than reference streams (Fig. 23). Blackbird Creek had the lowest value (71 out of a possible 215), and Big Deer and Fourth of July Creeks had the highest (189 and 191, respectively) (Table 35).

Table 33. Summary of habitat assessment category scores for each study stream in the Panther Creek drainage.

STATION	SUBSRT. COVER	EMBED.	FLOW VELOCITY	CANOPY COVER	CHANNEL ALTERATION	BOTTOM SCOUR	POOL RIFFLE	WIDTH DEPTH	BANK STABILITY	BANK VEG.	STREAM COVER	RIPARIAN WIDTH	TOTAL SCORE
Mining Impacted													
Upper Napias	20	19	16	19	11	12	12	15	10	9	10	7	160
Arnett	20	19	10	18	3	15	7	12	8	10	9	10	141
Lower Napias	20	11	10	14	8	11	3	3	5	5	5	2	97
SF Big Deer	2	0	11	17	5	0	8	13	10	9	9	6	90
Blackbird	14	18	7	4	2	6	3	7	4	4	1	4	74
Reference													
Fourth of July	20	20	20	20	15	15	15	14	10	10	10	7	176
WF Blackbird	20	20	15	19	15	14	12	15	10	10	10	8	168
Big Deer	20	20	17	19	13	14	14	14	10	9	9	9	168
Upper Blackbird	19	16	15	20	15	14	14	15	10	10	9	9	166
Moyer	18	20	10	17	13	15	8	13	10	9	9	8	150
Impacted mean	15.2	13.4	10.8	14.4	5.8	8.8	6.6	10.0	7.4	7.4	6.8	5.8	112.4
stddev	7.0	7.3	2.9	5.5	3.3	5.3	3.4	4.4	2.5	2.4	3.4	2.7	32.5
stderr	3.0	3.2	1.3	2.4	1.4	2.3	1.5	1.9	1.1	1.1	1.5	1.2	14.2
Reference mean	19.4	19.2	15.4	19.0	14.2	14.4	12.6	14.2	10.0	9.6	9.4	8.2	165.6
stddev	0.8	1.6	3.3	1.1	1.0	0.5	2.5	0.7	0.0	0.5	0.5	0.7	8.5
stderr	0.3	0.7	1.4	0.5	0.4	0.2	1.1	0.3	0.0	0.2	0.2	0.3	3.7

Table 34. Summary of habitat measures recorded for each study site in the Panther Creek drainage.

STATION	WIDTH/ DEPTH RATIO	MEAN WIDTH (m)	MEAN DEPTH (m)	% COVER	AFDM (g/m2)	CHL-a (mg/cm2)	Q (m3/s)	TEMP. (C)	SPECIFIC COND. (umhos)	ALKALINITY (mg/L)	TOTAL HARDNESS (mg/L)	pH	NO3 (mg/L)	PO4 (mg/L)	SUBSRT. (cm)	EMBED. (%)	SLOPE (%)	BOM (g/m2)
Mining Impacted																		
Lower Napias	14.9	4.7	0.16	40	2643	2.50	0.41	10.7	25	7	52.7	7.4	0.05	0.34	21.2	34.5	2.8	3.3
Upper Napias	7.5	3.0	0.15	60	2335	1.73	0.12	13.5	29	12	31.6	7.2	0.02	0.61	12.5	55.5	1.5	7.6
Arnett	16.8	4.7	0.19	50	1338	3.08	0.39	7.8	23	8	24.6	7.5	0.22	1.18	26.1	17.7	1.3	32.5
Blackbird	21.9	4.4	0.08	5	2856	1.45	0.08	8.5	147	5	52.7	6.2	0.03	0.24	21.2	35.5	1.8	5.5
South Fork Big Deer	23.9	2.6	0.11	50	7579	0.51	0.06	9.1	165	44	56.2	7.6	0.01	2.00	11.6	59.0	6.5	13.3
Reference																		
Big Deer	33.4	6.9	0.21	75	NA	NA	0.39	11.5	43	14	38.6	8.1	0.02	1.28	17.1	22.1	2.5	143.1
West Fork Blackbird	20.1	2.7	0.05	77	4840	23.07	0.02	6.7	60	17	56.2	7.7	0.01	0.02	20.9	40.8	2.5	59.6
Fourth of July	12.6	2.2	0.14	90	5371	13.95	0.05	7.4	54	22	77.3	7.4	0.01	1.88	14.1	26.5	2.8	113.3
Upper Blackbird	13.9	1.5	0.11	75	1040	3.01	0.03	8.2	58	18	38.6	7.6	0.01	0.07	11.9	44.3	8.5	21.5
Moyer	17.6	6.3	0.22	75	3726	7.06	1.02	10.3	38	13	38.6	7.3	0.01	1.25	23.5	18.0	1.3	77.9
Impacted mean	17.0	3.9	0.14	41.0	1837	2.41	0.21	9.9	78	15	43.5	7.2	0.07	0.87	18.5	40.4	2.8	12.4
stddev	5.8	0.9	0.04	19.1	2177	0.88	0.15	2.0	64	15	12.9	0.5	0.08	0.65	5.6	15.2	1.9	10.6
stderr	2.5	0.4	0.02	8.3	223	0.30	0.07	0.9	28	6	5.6	0.2	0.03	0.28	2.4	6.6	0.8	4.6
Reference mean	19.5	3.9	0.15	78.4	2420	11.54	0.30	8.8	51	17	49.9	7.6	0.01	0.90	17.5	30.3	3.5	83.1
stddev	7.4	2.2	0.06	5.9	2115	8.27	0.38	1.8	9	3	15.3	0.3	0.00	0.73	4.3	10.4	2.6	42.1
stderr	3.2	1.0	0.03	2.5	1080	5.15	0.17	0.8	4	1	6.6	0.1	0.00	0.32	1.9	4.5	1.1	18.3

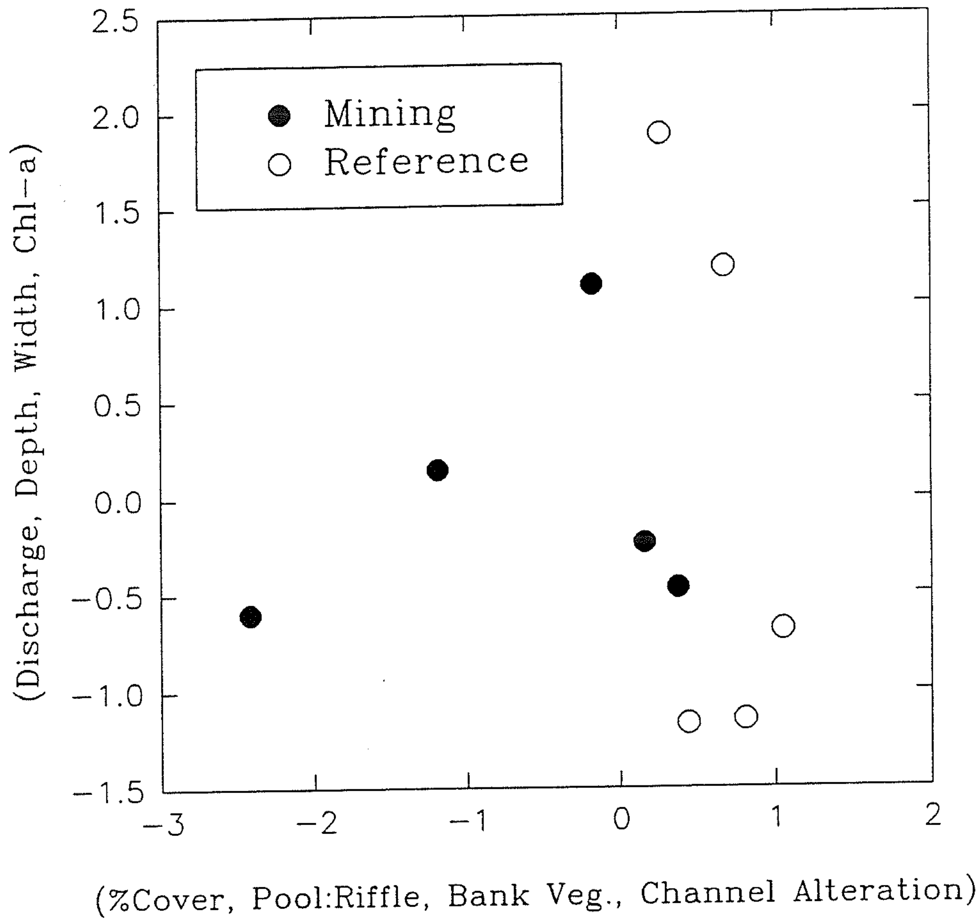

Fig. 22. PCA scatterplot based on habitat measures for study streams in the Panther Creek drainage.

Table 35. Scores for important habitat variables based on statistical analyses for tributaries of Panther Creek.

STATION	MEAN WIDTH (m)	SCORE	MEAN DEPTH (m)	SCORE	% COVER	SCORE	CHL-a (mg/cm^2)	SCORE	ALKALINITY (mg/L) (CaCO3)	SCORE	pH	SCORE	FLOW VELOCITY	CANOPY COVER	CHANNEL ALTER	POOL/ RIFFLE	WIDTH/ DEPTH	BANK STABILITY	BANK VEGETATION	STREAM COVER	RIPARIAN WIDTH	TOTAL SCORE
Mining Impacted																						
Upper Napias	3.0	10	0.15	10	60	5	1.73	5	12	5	7.2	5	16	19	11	12	15	10	9	10	7	149
SF Big Deer	2.6	10	0.11	10	50	5	0.51	5	44	15	7.6	10	11	17	5	8	13	10	9	9	6	143
Arnett	4.7	10	0.19	10	50	5	3.08	5	8	5	7.5	10	10	18	3	7	12	8	10	9	10	132
Lower Napias	4.7	10	0.16	10	40	5	2.50	5	7	5	7.4	10	10	14	8	3	3	5	5	5	2	100
Blackbird	4.4	10	0.08	5	5	5	1.45	5	5	5	6.2	5	7	4	2	3	7	4	4	1	4	71
Reference																						
Fourth of July	2.2	10	0.14	10	90	15	13.95	10	22	15	7.4	10	20	20	15	15	14	10	10	10	7	191
Big Deer	6.9	15	0.21	15	75	10	11.77	10	14	10	8.1	15	17	19	13	14	14	10	9	9	9	189
WF Blackbird	2.7	10	0.05	5	77	10	23.07	15	17	10	7.7	10	15	19	15	12	15	10	10	10	8	174
Upper Blackbird	1.5	5	0.11	10	75	10	3.01	5	18	10	7.6	10	15	20	15	14	15	10	10	9	9	167
Moyer	6.3	15	0.22	15	75	10	7.06	10	13	5	7.3	5	10	17	13	8	13	10	9	9	8	157
Reference mean	3.91		0.15		78.4		11.77		16.80		7.62		15.40	19.00	14.20	12.60	14.20	10.00	9.60	9.40	8.20	
stddev	2.21		0.06		5.85		6.80		3.19		0.28		3.26		0.98	2.50	0.75	0.00	0.49	0.49	0.75	
stderr	0.96		0.03		2.5		3.04		1.39		0.12		1.42	0.48	0.43	1.09	0.33	0.00	0.21	0.21	0.33	
+90%CL	6.00		0.21		83.9		17.33		19.81		7.88											
-90%CL	1.82		0.09		72.9		6.21		13.79		7.36											
SCORE 15	>6.0		>0.20		>84		>17.3		>19.8		>7.9											
10	1.8-6.0		0.09-0.20		73-84		6.2-17.3		13.8-19.8		7.4-7.9											
5	<1.82		<0.09		<73		<6.2		<13.8		<7.4											

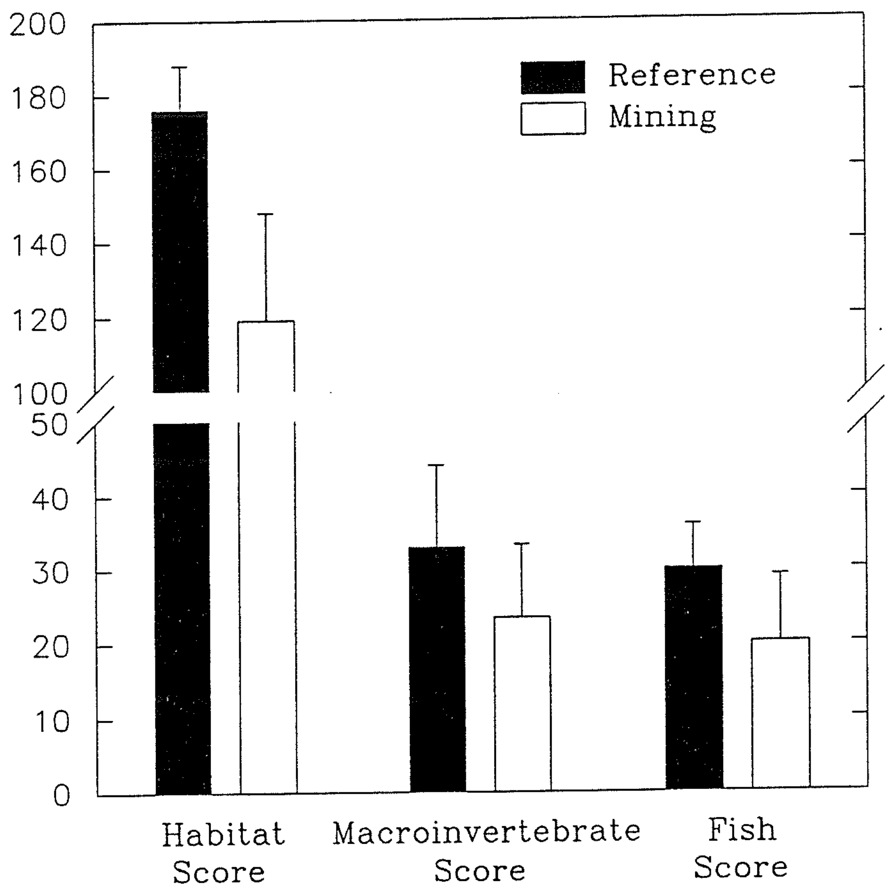

Fig. 23. Mean scores for respective metrics for mining–impacted and reference streams of the Panther Creek drainage. Error bars equal +1 standard deviation from the mean; n=5 for both impacted and reference streams.

Macroinvertebrates: Mining-impacted streams displayed lower values for macroinvertebrate density, species richness, diversity, number of EPT, %scrapers, and S/F ratios than found in reference streams (Table 36). However, these differences were primarily attributed to the two chemically-impacted streams being devoid of macroinvertebrates. Principal components analysis clearly separated stream types with the first two axes explaining 99% of the variation (Fig. 24). The more pristine streams showed greater values of %scrapers, %shredders, shredder/total ratios, EPT/Chironomidae ratios, and %EPT. The two chemically-influenced streams were distinctly placed from all other sites (Fig. 24). Metric scores were derived for the macroinvertebrate variables found important based on the PCA results (Table 37), with mining-impacted streams showing a significantly lower mean biotic metric score than reference streams (Fig. 23). In addition, there was a positive relationship when the macroinvertebrate metric score was regressed against the derived habitat assessment score (Fig. 25).

Fish: As with macroinvertebrates, the chemically-influenced streams were devoid of fishes (Table 38). Only five taxa of fish were collected from the study streams consisting 4 species of trout and the mottled sculpin. Of interest, trout in mining-impacted streams primarily were introduced species (although the rainbow trout actually may have been juvenile steelhead: see discussion) while the native bull trout were found in reference streams (Table 39). Further, a previously unrecorded population of bull trout were found in Upper Napias Creek, a stream showing a slight impact from mining. Bull trout also were collected in W.F. Blackbird Creek upstream of the tailings area. Average fish biomass (g/m^2) and salmonid biomass was lower in mining streams than in reference streams.

Principal components analysis separated streams based on variables of biomass, salmonid density, and introduced taxa with the first two axes explaining 98% of the variation (Fig. 26). Metric scores were derived for the important variables based on the PCA results with a maximum score of 45 attainable (Table 40). Upper Blackbird and Fourth of July Creeks displayed the highest

Table 36. Summary of macroinvertebrate metrics used to compare streams in the Panther Creek drainage.

STREAM	DENSITY (no./M^2)	RICHNESS	H'	SIMPSON'S	(%) DOMINANCE	EPT	%EPT	(%) SCRAPERS	(%) FILTERERS	(%) SHREDDERS	(%) PREDATORS	(%) MINERS	(%) GATHERERS	S/F RATIO	EPT/C	HBI	CBS	SHREDDERS/ TOTAL
Mining Impacted																		
Lower Napias	552	20	0.97	0.17	0.35	15	0.34	0.11	0.03	0.09	0.15	0.52	0.10	4.0	2.1	6.3	117.8	0.09
Upper Napias	800	22	1.05	0.13	0.27	11	0.26	0.08	0.03	0.01	0.36	0.39	0.13	3.0	2.1	6.5	95.9	0.01
Arnett	2099	20	1.06	0.12	0.27	8	0.35	0.07	0.02	0.06	0.38	0.37	0.10	4.5	1.3	6.3	78.1	0.06
Blackbird	3	1	0.00	1.00	0.00	0	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.0	0.0	8.0	46.3	0.00
SF Big Deer	0	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.00
Reference																		
Big Deer	10793	19	1.09	0.10	0.11	11	0.41	0.28	0.13	0.09	0.11	0.20	0.20	2.2	4.3	4.3	91.7	0.09
WF Blackbird	3873	16	0.81	0.21	0.21	10	0.44	0.28	0.01	0.12	0.37	0.22	0.01	42.5	2.1	6.0	96.6	0.12
Fourth of July	6603	18	1.08	0.11	0.20	13	0.42	0.15	0.00	0.10	0.24	0.36	0.15	0.0	2.7	5.8	103.3	0.10
Upper Blackbird	2311	18	0.87	0.21	0.35	12	0.29	0.03	0.00	0.06	0.27	0.62	0.02	0.0	1.1	7.4	59.6	0.06
Moyer	6374	16	0.69	0.34	0.53	10	0.13	0.05	0.02	0.01	0.12	0.75	0.06	2.6	0.6	8.6	90.3	0.01
Impacted mean	691	13	0.62	0.28	0.18	7	0.19	0.05	0.01	0.03	0.38	0.26	0.07	2.3	1.1	5.4	67.6	0.03
std	770	10	0.51	0.36	0.15	6	0.16	0.05	0.01	0.04	0.34	0.22	0.05	1.9	0.9	2.8	41.1	0.04
Reference mean	5991	17	0.91	0.19	0.28	11	0.34	0.16	0.03	0.07	0.22	0.43	0.09	9.4	2.2	6.4	88.3	0.07
std	2885	1	0.15	0.09	0.15	1	0.11	0.11	0.05	0.04	0.10	0.22	0.08	16.6	1.3	1.5	15.0	0.04

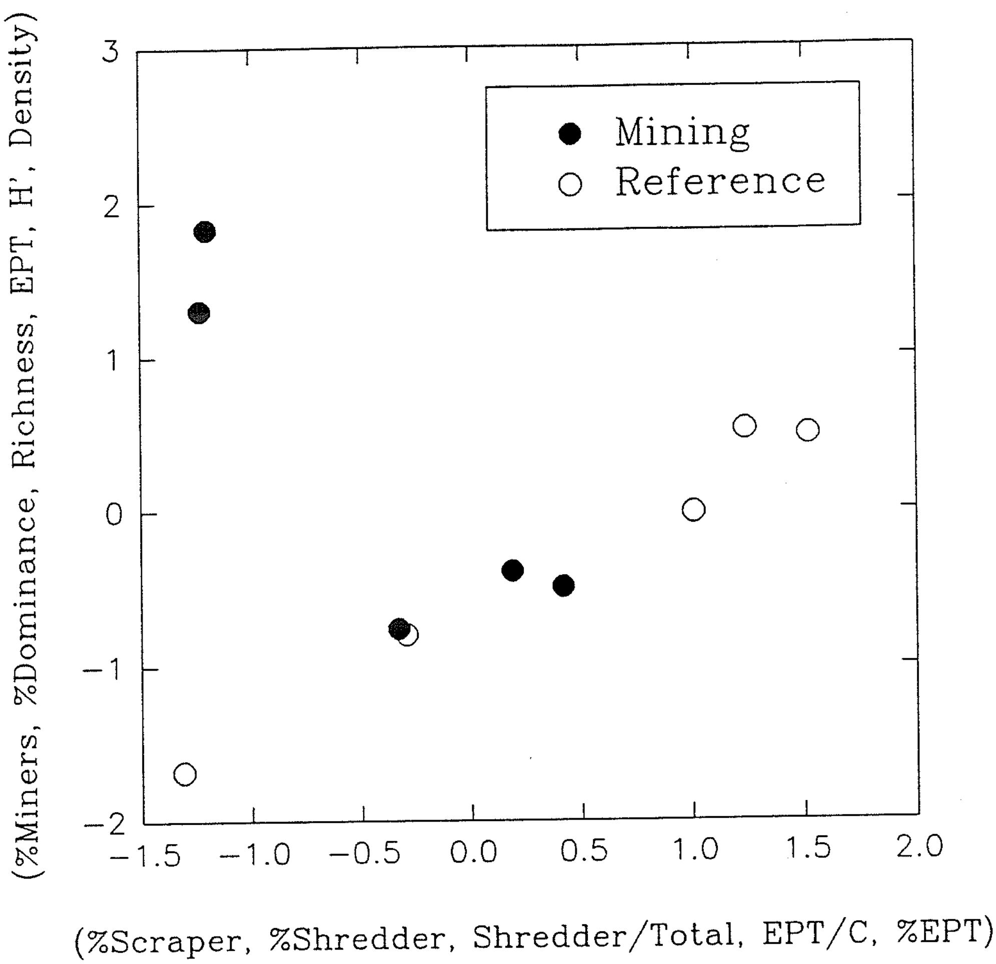

Fig. 24. PCA scatterplot based on macroinvertebrate metrics for mining–impacted and reference streams of the Panther Creek drainage.

Table 37. Scores for macroinvertebrate metrics shown important based on PCA analyses for Panther Creek tributaries. SC=Score.

STREAM	TYPE	DENSITY	SC	RICHNES	SC	H'	SC	(%) DOMINANCE	SC	EPT	SC	%EPT	SC	(%) SCRAPERS	SC	(%) SHREDDERS	SC	(%) MINERS	SC	EPT/C RATIO	SC	SHREDDER TOTAL	SC	TOTAL SCORE
Mining Impacted																								
Lower Napias		552	1	20	5	0.97	3	0.35	3	15	5	0.34	3	0.11	3	0.09	3	0.52	3	2.07	1	0.09	3	33
Upper Napias		800	1	22	5	1.05	5	0.27	3	11	3	0.26	3	0.08	3	0.01	1	0.39	5	2.06	1	0.01	1	31
Arnett		2099	1	20	5	1.06	5	0.27	3	8	1	0.35	3	0.07	3	0.06	3	0.37	5	1.31	1	0.06	1	31
Blackbird		3	1	1	1	0.00	1	0.00	1	0	1	0.00	1	0.00	1	0.00	1	0.00	1	0.00	1	0.00	1	11
SF Big Deer		0	1	0	1	0.00	1	0.00	1	0	1	0.00	1	0.00	1	0.00	1	0.00	1	0.00	1	0.00	1	11
Reference																								
Big Deer		10793	5	19	5	1.09	5	0.11	5	11	3	0.41	3	0.28	5	0.09	3	0.20	5	4.34	5	0.09	3	47
WF Blackbird		3873	3	16	1	0.81	3	0.21	3	10	3	0.44	3	0.28	5	0.12	5	0.22	5	2.13	3	0.12	5	39
Fourth of July		6603	3	18	3	1.08	5	0.20	3	13	5	0.42	3	0.15	3	0.10	3	0.36	5	2.66	3	0.10	3	39
Upper Blackbird		2311	1	18	3	0.87	3	0.35	3	12	3	0.29	3	0.03	1	0.06	3	0.62	3	1.10	1	0.06	1	25
Moyer		6374	3	16	1	0.69	1	0.53	1	10	3	0.13	1	0.05	1	0.01	1	0.75	1	0.61	1	0.01	1	15
Reference	mean	5991		17.4		0.91		0.28		11.2		0.34		0.16		0.07		0.43		2.17		0.07		
	stderr	1288		0.5		0.07		0.07		0.5		0.05		0.05		0.02		0.10		0.58		0.02		
	stddev	2885		1.2		0.15		0.15		1.2		0.11		0.11		0.04		0.22		1.31		0.04		
	+90%	8734		18.5		1.05		0.42		12.3		0.45		0.26		0.11		0.64		3.41		0.11		
	-90%C	3248		16.3		0.76		0.14		10.1		0.23		0.06		0.04		0.22		0.93		0.04		
SCORE	5	>8700		>18.5		>1.05		<0.14		>12		>0.45		>0.26		>0.11		<0.43		>3.4		>0.11		
	3	3250-8700		16.3-18.5		0.76-1.05		0.14-0.42		10-12		0.23-0.45		0.06-0.26		0.04-0.11		0.43-0.64		2.2-3.4		0.07-0.11		
	1	<3250		<16.3		<0.76		>0.42		<10		<0.23		<0.06		<0.04		>0.64		<2.2		<0.07		

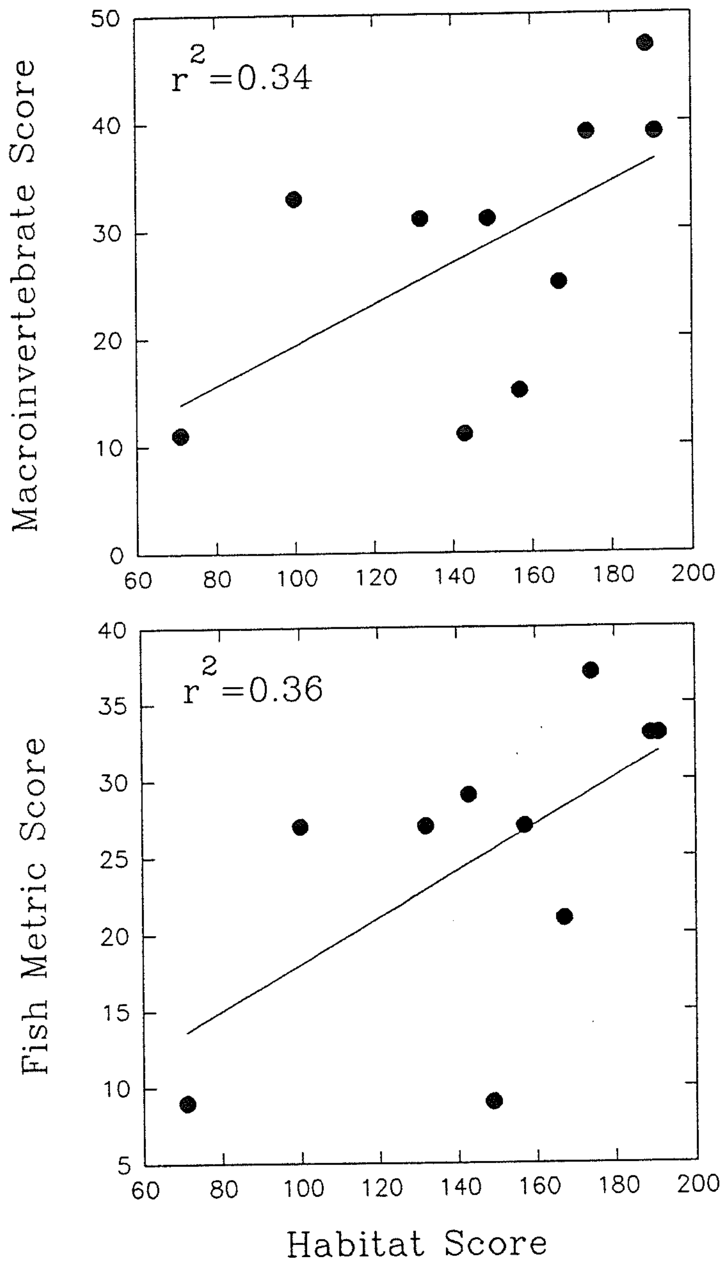

Fig. 25. Regression of habitat score against the fish metric score and the macroinvertebrate metric score for 10 tributaries of Panther Creek.

Table 38. Absolute number of fish collected in streams of the Panther Creek drainage. *NOTE: Tolerance, I=Intolerant, MI=Moderately Intolerant; Trophic guild, I=Invertivore C=Carnivore; Native/Introduced, N=Native, I=Introduced.

STREAM	DATE COLLECTE	BULL TROUT	RAINBOW TROUT	BROOK TROUT	CUTTHROAT TROUT	PAIUTE SCULPIN
TOLERANCE*		I	I	MI	I	MI
TROPHIC GUILD*		I/C	I/C	I/C	I/C	I
NATIVE/INTRODUCED*		N	I	I	N	N
Mining Impacted						
Arnett	930806		6	7		
Blackbird	930805					
Lower Napias	930806		9	8		
SF Big Deer	930808					
Upper Napias	930806	10				
Reference						
Big Deer	930808		14			
Fourth of July	930807	2	1			
Moyer	930807		3			26
Upper Blackbird	930805				5	
West Fork Blackbird	930805	2				

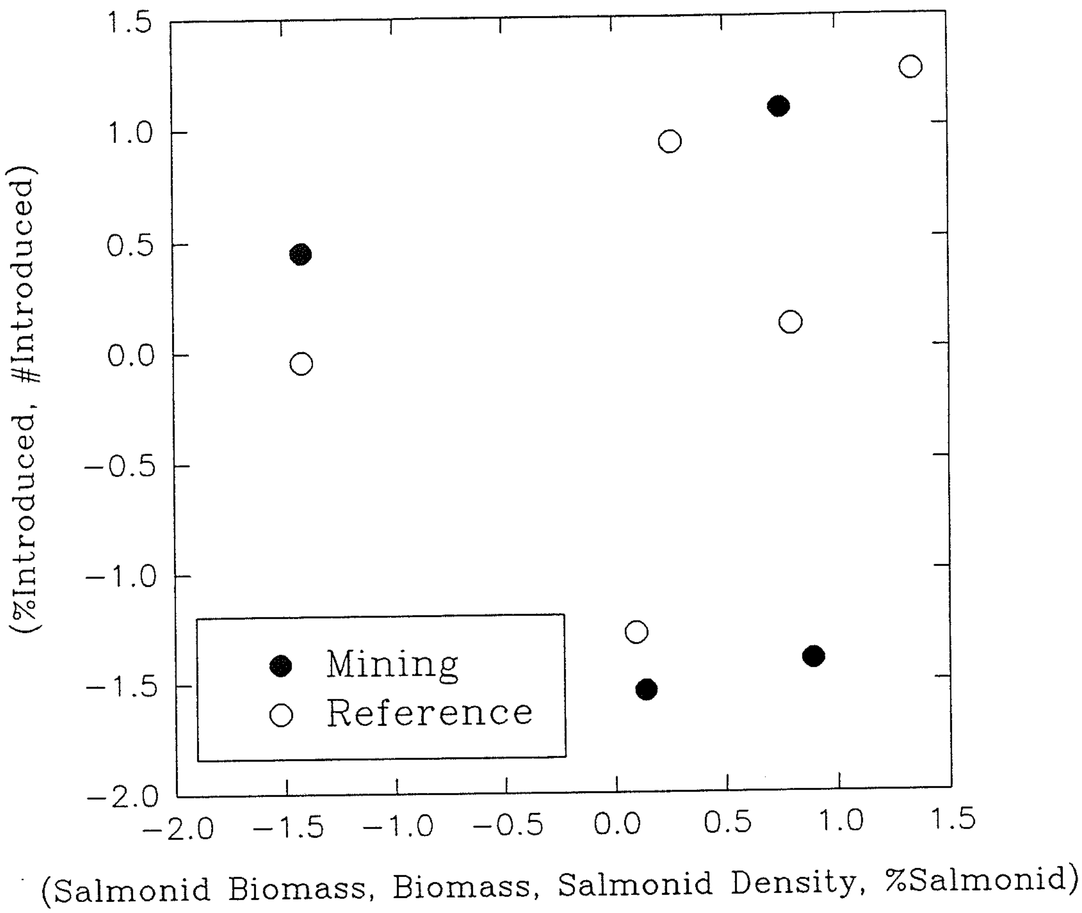

Fig. 26. PCA scatterplot based on fish metrics for study streams of the Panther Creek drainage.

Table 39. Absolute values for fish metrics for streams of the Panther Creek drainage.

STREAM	SPECIES RICHNESS	No. NATIVE SPECIES	No. INTRODUCED SPECIES	No. SALMONID SPECIES	No. BENTHIC INSECTIVORES	No. INTOLERANT SPECIES	% INTRODUCED SPECIES	% CARNIVORES	% INVERTIVORES	% SALMONIDS	DENSITY (no./m2)	BIOMASS (g/m2)	SALMONID DENSITY	SALMONID BIOMASS	CONDITION FACTOR
Mining Impacted															
Upper Napias	1	1	0	1	1	1	0	100	100	100	0.03	0.98	0.03	0.98	1.0
Lower Napias	2	0	2	2	1	2	100	100	100	100	0.03	1.37	0.03	1.37	1.8
Arnett	2	0	2	2	1	2	100	100	100	100	0.03	0.52	0.03	0.52	1.4
SF Big Deer	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.0
Blackbird	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.0
Reference															
WF Blackbird	1	1	0	1	1	1	0	100	100	100	0.02	1.89	0.02	1.89	1.2
Upper Blackbird	1	1	0	1	1	1	0	100	100	100	0.03	0.46	0.03	0.46	1.2
Fourth of July	2	1	1	2	2	2	50	100	100	100	0.04	1.11	0.04	1.11	1.1
Big Deer	1	0	1	1	0	1	100	100	100	100	0.03	0.52	0.03	0.52	1.6
Moyer	2	1	1	1	1	2	50	100	100	50	0.09	0.35	0.01	0.11	1.5
Impacted															
mean	1.0	0.2	0.8	1.0	0.6	1.0	40	60	60	60	0.02	0.58	0.02	0.58	0.8
stddev	0.9	0.4	1.0	0.9	0.5	0.9	49	49	49	49	0.02	0.54	0.02	0.54	0.7
stderr	0.4	0.2	0.4	0.4	0.2	0.4	22	22	22	22	0.01	0.24	0.01	0.24	0.3
Reference															
mean	1.4	0.8	0.6	1.2	1.0	1.4	40	100	100	90	0.04	0.87	0.02	0.82	1.3
stddev	0.5	0.4	0.5	0.4	0.6	0.5	37	0	0	20	0.03	0.57	0.01	0.62	0.2
stderr	0.2	0.2	0.2	0.2	0.3	0.2	17	0	0	9	0.01	0.26	0.00	0.28	0.1

Table 40. Scores for fish metrics shown important based on statistical analyses for tributaries of Panther Creek.

STREAM	No. INTRODUCED SPECIES	SCORE	No. SALMONID SPECIES	SCORE	(%) INTRODUCED SPECIES	SCORE	(%) CARNIVORES	SCORE	(%) INVERTIVORES	SCORE	(%) SALMONIDS	SCORE	BIOMASS (g/m2)	SCORE	SALMONID DENSITY	SCORE	SALMONID BIOMASS	SCORE	TOTAL SCORE
Mining Impacted																			
Upper Napias	0	1	1	3	0	5	100	3	100	3	100	5	0.98	3	0.03	3	0.98	3	29
Lower Napias	2	1	2	5	100	1	100	3	100	3	100	5	1.37	3	0.03	3	1.37	3	27
Arnett	2	1	2	5	100	1	100	3	100	3	100	5	0.52	3	0.03	3	0.52	3	27
South Fork Big Deer	0	1	0	1	0	1	0	1	0	1	0	1	0.00	1	0.00	1	0.00	1	9
Blackbird	0	1	0	1	0	1	0	1	0	1	0	1	0.00	1	0.00	1	0.00	1	9
Reference																			
West Fork Blackbird	0	5	1	3	0	5	100	3	100	3	100	5	1.89	5	0.02	3	1.89	5	37
Upper Blackbird	0	5	1	3	0	5	100	3	100	3	100	5	0.46	3	0.03	3	0.46	3	33
Fourth of July	1	3	2	5	50	3	100	3	100	3	100	5	1.11	3	0.04	5	1.11	3	33
Big Deer	1	3	1	3	100	1	100	3	100	3	100	5	0.52	3	0.03	3	0.52	3	27
Moyer	1	3	1	3	50	3	100	3	100	3	50	1	0.35	3	0.01	1	0.11	1	21
Reference																			
mean	0.60		1.20		40.0		100		100		90		0.87		0.02		0.82		
stderr	0.22		0.18		16.7		0		0		9		0.26		0.00		0.28		
stddev	0.49		0.40		37.4		0		0		20		0.57		0.01		0.62		
+90%CL	1.07		1.59		76.2		100		100		109		1.42		0.03		1.42		
-90%CL	0.13		0.81		3.8		100		100		71		0.31		0.02		0.21		
SCORE																			
5	<0.13		>1.60		<40		>100		>100		>99		>1.42		>0.03		>1.42		
3	0.13-1.07		.81-1.60		40-76		100		100		70-99		0.31-1.42		0.02-0.03		0.21-1.42		
1	>1.07		<.81		>76		<100		<100		<70		<0.31		<0.02		<0.21		